U.S. Environmental Protection Agency
Office of Research and Development

BOARD OF SCIENTIFIC COUNSELORS
GLOBAL CHANGE SUBCOMMITTEE

Meeting Summary
September 26-28, 2005
Alexandria, VA

MONDAY, SEPTEMBER 26
Dr. Milton Russell, Chair, Global Change Subcommittee

Dr. Russell welcomed the Subcommittee members to the first day of the meeting and announced that this was a public meeting. He introduced Dr. Janet Gamble, the Designated Federal Officer (DFO) for the Global Change Subcommittee. The Subcommittee members included: John Balbus, M.D., M.P.H., Environmental Defense; Charles Coutant, Ph.D., Oak Ridge National Laboratory; Clifford Duke, Ph.D., Ecological Society of America; Claudia Nierenberg, M.A., National Oceanic and Atmospheric Administration (NOAA); Ruth Reck, Ph.D., University of California at Davis; and Robert Wilkinson, Ph.D., University of California at Santa Barbara.

DFO Welcome and Charge
Dr. Janet Gamble, U.S. Environmental Protection Agency (EPA), Office of Research and Development (ORD)

Dr. Gamble explained that the Board of Scientific Counselors (BOSC) is a federal advisory committee that provides independent scientific peer review and advice to the Office of Research and Development (ORD). The BOSC Executive Committee established the Global Change Subcommittee to review the Global Change Research Program and to provide a review report responding to a predetermined set of charge questions. The Executive Committee will review, revise, and approve the report, which will be sent to the Assistant Administrator (AA) for ORD. Whereas the role of the BOSC is to provide advice and recommendations to ORD, the rights of decisionmaking and program implementation remain with EPA.

Dr. Gamble further explained that, as DFO to the Subcommittee, she serves as a liaison between the Subcommittee and the Agency and ensures the Subcommittee's compliance with the requirements of the Federal Advisory Committee Act (FACA), which include the following provisions:

- ✧ All Subcommittee meetings on substantive issues, whether by phone, e-mail, or in person, are open to the public, including any group communications involving at least half of the Subcommittee. Issues that are solely administrative or preparatory are exempt from this requirement.

- ✧ A *Federal Register* notice must announce all Subcommittee meetings and calls 15 calendar days in advance.

- ✧ The DFO must approve the agenda and attend all meetings and calls. The Subcommittee Chair must certify the meeting minutes within 90 days of the meeting.

- ✧ All Advisory Committee documents must be made available to the public.

- ✧ The DFO must ensure that all appropriate ethics regulations are satisfied.

Dr. Gamble stated that all Subcommittee members have filed a standard governmental financial disclosure report and have completed the required annual ethics training. She stated that this was the third public meeting of the BOSC Global Change Subcommittee. The Subcommittee held an initial conference call on August 4, 2005, and a second conference call on September 13, 2005. These three meetings were listed in the *Federal Register* in July 2005. Additional meetings may be scheduled according to need. It is anticipated that the Subcommittee will produce a draft detailed outline following this face-to-face meeting and a draft final report during the period from late November through early December 2005. The draft final report will be presented to the BOSC Executive Committee for deliberation at the January 2006 Executive Committee meeting. Dr. Gamble pointed out that the current Subcommittee meeting was being recorded and detailed meeting minutes will be prepared.

Dr. Gamble stated that she had not received any requests from members of the public to participate in the Subcommittee meeting; however, time will be allotted for public comments on Day 2 of the meeting, limited to 3 minutes per person.

ORD's Welcome
Dr. William Farland, EPA, ORD

Dr. Russell introduced Dr. William Farland, Acting Deputy Assistant Administrator (DAA) for Science in ORD. Dr. Farland stressed the importance of the Subcommittee's contribution to ORD and the Global Change Research Program. He stated that ORD seeks the Subcommittee's input regarding the program's impact and outcomes, and this review will contribute to the evolution and future direction of the program. Dr. Farland noted that this program is part of the larger federal global change research effort. EPA has played a small but critical role in the federal government's response to global change.

Currently, ORD is considering the next phase of budget preparations. Dr. Farland stated that the 2007 budget is being formulated, and work soon will begin on the 2008 budget. Because of fiscal constraints and pressures on the program, good, reasoned decisions on how to advance the program and leverage resources with other federal agencies will be particularly important. Dr. Farland stated that the Global Change Subcommittee's review will contribute to the documentation for the Office of Management and Budget's (OMB) Program Assessment Rating Tool (PART) review. The PART review has significant implications for future budget considerations.

Dr. Farland explained that this is the sixth BOSC program review. He assured the Subcommittee members that ORD will respond to their recommendations and incorporate them into the Agency's plans. A mid-cycle review is anticipated in approximately 2 years to discuss the programs' progress toward meeting Subcommittee recommendations. Dr. Farland recommended that, for this face-to-face Global Change Subcommittee meeting, the participants focus on the charge questions.

Dr. Coutant asked if there were any new funding possibilities in the aftermath of Hurricanes Katrina and Rita. Dr. Farland replied that the 2006 budget might be revised because of the need to fund work and aid in the Gulf Coast region. The research and development team has made significant contributions in the areas of technical assistance and evaluation of monitoring data. The magnitude of the debris program, for instance, will require the Agency to play a larger role in the cleanup.

Dr. Russell asked how the Agency was responding to the tension between present and future needs. Dr. Farland explained that the greatest challenge has been the effort required to identify future problems and develop solutions while maintaining the balance between program-related work and basic research that advances science. EPA has kept this balance by remaining flexible regarding programs and being responsive to breaking needs for technical assistance, such as the events of September 11, 2001, and Hurricanes Katrina and Rita. Dr. Farland added that Congress recognizes EPA's role in working with other organizations and agencies on a short-term basis when needed, and it has kept funding in the 2006 appropriations for such needs. Currently, ORD is focusing on EPA's National Homeland Security Research Center. Dr. Farland explained that the Center has been very responsive to the needs of the homeland security community and to Presidential directives that have specific EPA mandates.

Global Change Research Program: Relevance, Quality Performance, and Scientific Leadership
Dr. Joel Scheraga, EPA, ORD

Dr. Russell introduced Dr. Joel Scheraga, the National Program Director (NPD) for the Global Change Research Program at the National Center for Environmental Assessment (NCEA). Dr. Scheraga thanked members of the Subcommittee for the work they have done and the important work they will be doing in conducting this review.

Dr. Scheraga stated that his presentation will address the Subcommittee's two primary questions: (1) Is the program engaged in the "right" work? and (2) Does the program conduct its work well? To address these questions, he will discuss the program's relevance and focus on issues of quality, performance, and scientific leadership.

Dr. Scheraga described the Global Change Research Program as an assessment-oriented program that is focused primarily on understanding the potential consequences of global change within the United States. The program's ultimate goal is to inform decisionmakers in a timely and useful way so that effective decisions can be made regarding adaptation options that will reduce risk and maximize opportunities presented by global change. The program has four areas of focus: air quality, water quality, ecosystems, and human health, as well as efforts in place-based integration and decision support.

In 1998, the Global Change Research Program underwent a major reorientation from an exploratory, process-based, research program toward an assessment-oriented program. This shift was in response to (1) an increased emphasis on assessment that was occurring in the U.S. Global Change Research Program (USGCRP), which now is the Climate Change Science Program (CCSP); and (2) a critical peer review in 1997 that suggested structural as well as programmatic changes. Between 1998 and 2000, a Research Strategy was developed. A peer review in 2001 endorsed the program's movement toward an assessment orientation, which was

considered to reflect the Agency's capabilities and interests and fit into the national global change effort more effectively.

In 2001, the National Research Council (NRC) recommended that the program undertake the following four key actions:

- ✧ Define and carry out regional and sectoral multiple-stress research programs.
- ✧ Develop improved assessment capabilities for integrating scientific knowledge into effective decision-support systems.
- ✧ Ensure an "intimate connection" between research, operational activities, and decision support.
- ✧ Participate in and support interdisciplinary research.

In September 2005, the President of the National Academy of Sciences (NAS), Dr. Ralph Cicerone, urged the program to focus on "low hanging fruit" and make a greater effort to understand the consequences of climate change on a regional scale.

Program Relevance

Dr. Scheraga explained that the program has a very well-defined definition of relevance. Because the program is stakeholder oriented, it is considered relevant if timely and useful information is provided to stakeholders. Stakeholders and their needs change over time. This presents challenges because stakeholders guide research and assessments. Dr. Scheraga added that there are several general categories of stakeholders, including:

- ✧ EPA program offices
- ✧ EPA regional offices
- ✧ The CCSP
- ✧ The Administration
- ✧ Regional, state, and local decisionmakers
- ✧ The international community

Dr. Scheraga commented that the program (1) has a well-defined focus, specifically on issues of greatest concern to clients/stakeholders; (2) meets the needs of clients/stakeholders in a timely and useful way; and (3) is able to facilitate meaningful outcomes that improve and protect human health and the environment. Dr. Scheraga stated that the role of the Global Change Research Program is to provide information to decision makers but not to make recommendations. He added that the program focuses on impacts and adaptation, but is not permitted to focus on greenhouse gas mitigation.

Does the Program Conduct Its Work Well?

Dr. Scheraga commented that the major challenge is to do the best job possible with a very small program. The Global Change Research Program represents approximately 1 to 2 percent of the total CCSP budget and has a workforce of approximately 45 full time employees (FTEs). When the program was reoriented in 1998, funding increased to approximately $23 million. Since

then, it has fluctuated with the change in administrations but overall has remained fairly steady. Dr. Scheraga noted that the ecosystem and air quality programs receive the most funding, and approximately one-third of the budget funds the Science To Achieve Results (STAR) Program extramural grants.

Dr. Scheraga explained that quality is ensured, in part, by the way the program is managed. All major EPA programs have an NPD who provides scientific leadership; serves as the primary interface between the program and its clients; helps set program priorities, resource levels, and budget allocations; and ensures that the highest quality and most relevant research is performed in support of EPA's mission.

Dr. Scheraga noted that part of the challenge for the program is to integrate across the five ORD laboratories and centers, each of which has expertise in a specific discipline. The program is coordinated with the CCSP and the other CCSP agencies, and there is close coordination and leveraging of activities through CCSP workgroups. The program also identifies research gaps that are not appropriate for EPA's Global Change Research Program. Dr. Scheraga explained that the program ensures quality by leveraging scientific expertise with the external academic community and other research institutions. All Agency extramural research, including STAR grants, is acquired through open competition. He noted that STAR grants provide ongoing, long-term support for selected topic areas.

The issue of uncertainty has become a major challenge in the global community. Dr. Scheraga explained that the science is not available yet to make predictions; however, the program uses a technique in which scenario analyses lead to qualitative information. Researchers also are learning how to quantify, characterize, and communicate uncertainties more effectively. He emphasized that through these techniques, EPA provides valuable insights to decisionmakers. The program addresses such questions as:

- ✧ Is climate change a potential issue of concern?
- ✧ Can we better understand the vulnerability of a system to climate variability and change?
- ✧ Are there win-win opportunities for increasing resilience to both climate variability and climate change?
- ✧ Are there actions that will foreclose future options?
- ✧ Can we identify potential maladaptive practices?

Dr. Scheraga stressed that the Global Change Research Program is committed to the highest standards of scientific excellence. This is accomplished through a rigorous, open, and inclusive peer review of all components, including: (1) long-term research strategy; (2) all final products (e.g., quality assurance plans and peer-review plans); (3) models (e.g., CMAQ, MARKAL database); (4) periodic reviews of program progress; and (5) periodic reviews of specific laboratories and centers. The FACA process for production of CCSP synthesis and assessment products and the competitive solicitations for extramural research ensure that all program work is conducted to the most rigorous standards.

Dr. Scheraga reviewed several components of the Global Change Research Program, including air quality, water quality, ecosystems, the Coral Reef Task Force, and human health. He noted that the focus areas are not "stove-piped" and that EPA realizes they are interrelated.

Air Quality

The goal of the air quality focus area is to assess the potential impacts of global change on air quality in the United States. By 2007, an interim assessment will be completed that will examine the partial effects of climate change on air quality. By 2010, a more complete assessment will be developed that examines other stressors, such as land use change, biogenic emissions, socioeconomic changes, and the effects of global change on air quality. Currently, EPA is the only agency analyzing the effects of climate change on air quality rather than the effects of air quality on climate change.

Useful results, such as meteorological downscaling, have been delivered to the scientific community and to decisionmakers. Models (e.g., the New England Energy-Environmental Model) and Web-based tools (e.g., a wildfire management tool) also have been provided through both the STAR Program and the intramural program.

Water Quality

The goal of the water quality focus area is to assess the potential impacts of global change on water quality in the United States. This year, the first assessment is being produced on the consequences of global change for water quality related to pollutants and microbial pathogens. By 2007, working in partnership with EPA's Office of Water (OW), the program expects to develop a BASINS decision support tool for incorporating climate variability and change into water management decisions. By 2008, an evaluation is expected on the consequences of global change for water quality related to biocriteria. Dr. Scheraga commented that much work has been accomplished and information is being delivered in a timely manner in the water quality area, despite a very small budget and a limited number of scientists working in this sector.

Ecosystems

The goal of the ecosystems focus area is to develop, by 2008, information and tools that managers will use in decisionmaking for adapting to the effects of global change, particularly on aquatic ecosystems. The first report, which will develop and evaluate information and tools on global change impacts and adaptation options in key watersheds, will be delivered in 2006.

This focus area has excelled at developing processes for engaging stakeholders on an ongoing basis to perform assessments and develop insights for decisionmakers. Decision support tools, such as a watershed yield calculator and a watershed evaluation and planning tool (WEAP), assist managers in evaluating the effects of climate change and vegetation management on base flow and in-stream flows.

U.S. Coral Reef Task Force

The U.S. Coral Reef Task Force is an example of EPA's interagency and international collaboration. As part of the U.S. Coral Reef Task Force, EPA worked with the Great Barrier Reef Marine Park Authority to develop a reef manager's guide to help protect reefs against global change, including climate change.

Human Health

The Agency has committed to evaluate, on an ongoing basis, the potential consequences of climate change for human health. In 2001, EPA produced the first U.S. Health Sector Assessment as part of the larger U.S. National Health Sector Assessment. This identified groups at risk, key research areas, and public health measures that could improve the nation's resilience to risks. The result is that, in 2005, much of the U.S. population is protected against adverse health outcomes associated with weather and/or climate. In collaboration with Johns Hopkins University, EPA has developed risk maps, which are being used by the U.S. Department of Health and Human Services (HHS) in the Southwest for disease prevention.

Dr. Scheraga noted that the Global Change Research Program is identified strongly with the regional assessment work. As part of the U.S. National Assessment, the program, in partnership with universities, completed regional assessments for the Great Lakes, Mid-Atlantic, and Gulf Coast regions. The program continues to function in each of these three regions with a Phase II round of assessments. Dr. Scheraga commented that a fundamental question is whether the program should continue to focus at the regional scale. If so, are these the right regions to highlight, or should research be focused in other areas?

Dr. Scheraga remarked there are many different types of scientific leadership. Within the larger global change research community, EPA has been a leader in the development and implementation of the science of assessment. In agencies such as NOAA, the National Aeronautics and Space Administration (NASA), and the NRC, the science of decision support is being developed along with the provision of decision support. Within the CCSP, EPA has taken a leadership role with the U.S. National Assessment, the development of the 10-year Strategic Plan, and the synthesis and assessment products. EPA also has provided a leadership role in creating stakeholder processes and partnering with the international community. Dr. Scheraga added that the Global Change Research Program also has fostered development of the next generation of scientists at universities and research institutions.

Dr. Scheraga noted the dynamic nature of the Global Change Research Program. The program responds to stakeholders' evolving needs while preserving its basic scientific research. The evolution toward decision support has two goals: (1) to advance the science of decision support both for EPA and the CCSP, and (2) to provide and improve decision support work.

Dr. Balbus asked about employees in the program. Dr. Scheraga replied that many were scientists but some provided administrative and technical support. Dr. Balbus noted that there is a strong relationship between advancing decision support and stakeholder involvement. He asked how stakeholders and their decision needs are identified. Dr. Scheraga explained that determining who the relevant stakeholders are, how they are engaged in specific areas, and how to respond to their changing needs varies among focus areas. For example, it remains a challenge for the ecosystem workgroup to identify the most appropriate areas in which to work and stakeholders to include.

Ms. Nierenberg asked whether stakeholders were brought into the evaluation process and, if so, how this was done. Dr. Scheraga replied that stakeholders have been brought into the process of evaluating the effectiveness of adaptation strategies in a limited way; the program only recently arrived at the evaluation point.

Dr. Russell suggested that EPA's role, particularly the role of policy analysis, traditionally has been to represent the people who have not been heard. He asked how EPA is addressing the public at large or the long-term interests of those who are not highly visible, including those whose needs may be on a smaller scale. Dr. Scheraga emphasized that EPA is working in several areas to ensure that such groups and communities have a collective voice. He added that the CCSP now recognizes that, as the decision support area becomes a primary focus, identification of relevant stakeholders emerges as a central challenge to the science.

Air Quality Focus Area
Dr. Anne Grambsch, EPA, ORD

Dr. Anne Grambsch stated that the ultimate goal of air quality managers is to use the scientific information, models, and tools that are being developed within the Agency to protect air quality. There are two major assessment products, the 2007 Air Quality Assessment that will focus only on climate changes and a 2010 assessment that will incorporate emission changes. There are, however, a number of interim products, such as the technology assessments and the regional air quality modeling, which are valuable stand-alone products and generate information that is useful to stakeholders. Dr. Grambsch noted that the program views its work as ongoing and part of an integral process between the research and assessment communities to improve both the science and the process of assessment. Because the science will continue to improve, the program developed an integrated assessment framework that will allow the incorporation of new science as it is created. Results from the air quality assessments will be used in other focus areas, the human health and ecosystem focus areas in particular.

Dr. Grambsch explained that the air quality program examines the impact of global-scale processes on regional-scale processes. The program does not investigate the impact of regional changes on global conditions. The following three types of linkages are being investigated: (1) the chemistry and boundary conditions, which account for the chemistry and air pollution that flow into the air space over the United States; (2) the scale used for global circulation models, which often is too coarse for use in air quality models; and (3) global- and regional-scale driver scenarios. EPA has substantial expertise in regional-scale processes but not in global-scale processes. In the global-scale area, the program is collaborating with national laboratories, other federal agencies, and the academic community.

Dr. Grambsch noted that there have been significant challenges in implementing an integrated framework. She commented that linking global processes to regional processes has not been a simple undertaking and has required the program to extend its models to accomplish this. The time horizon of 50 years into the future was a compromise. Dr. Grambsch explained that the time horizon had to be short enough for credible economic, technological, and emission projections but long enough for a discernable climate change signal. The development of high-resolution inputs poses challenges when creating the downscaling. She pointed out that the computational resources and the data transfer issues are not trivial, particularly when looking at multiple data years.

Dr. Grambsch explained that there are substantial uncertainties in the components of the assessment and in the linkages. She explained that the program will have to be very careful when characterizing results. Results cannot be described as predictions of the future but rather as possible effects on the climate if certain conditions exist. Ultimately, the program would like to

develop a strategy for handling uncertainty that can be imbedded into the assessment framework. Currently, three major activities are underway to address the issue of uncertainty, including:

- ✧ Multiple, complementary projects.

- ✧ Uncertainty workshops and literature review.

- ✧ Active exploration of modeling frameworks, methodologies, and tools to characterize uncertainty, propagate uncertainty, and analyze results, and incorporate consideration of uncertainty into decisionmaking.

Dr. Grambsch explained that there are several expected outcomes from the air quality program. One is to raise awareness in the air quality community (i.e., managers, researchers, and decisionmakers) of the potential impact of climate change on air quality. The program also is working with the Office Air and Radiation (OAR), both as a collaborator and a stakeholder, to design effective control strategies for improved air quality using technology assessments and databases. Dr. Grambsch noted that the program is creating specific tools to understand the impact of climate change at a regional level. Currently, the program also is contributing directly, through two STAR grants, to the California Air Resources Board's assessment of impacts of climate on air quality.

The program's air quality work contributes to several CCSP areas, including atmospheric composition, human contributions and responses, decision support, and the effects of global change. Three key offices within OAR—the Office of Air Quality Planning and Standards, the Office of Transportation and Air Quality, and the Office of Atmospheric Programs—are viewed as key stakeholders, as are the Northeast States for Coordinated Air Use Management (NESCAUM), the California Air Resources Board, and the Illinois State Water Survey. Future stakeholders will be identified through decision assessment.

Ecosystems Focus Area
Dr. Susan Julius, EPA, ORD

Dr. Susan Julius stated that she would address the following three questions concerning the ecosystem focus area:

- ✧ Why focus on ecosystems?
- ✧ How is the ecosystem work being conducted?
- ✧ What environmental outcomes are being achieved?

Dr. Julius explained that EPA is part of a group of federal agencies that perform ecosystem research through the CCSP, but it is unique because it is both a regulatory and a research agency that takes an ecosystems approach to environmental protection. Within that approach, the ecosystems program focuses on aquatic ecosystems because of EPA's mandate to protect the nation's water quality and the habitat of species that live in or on the water. The focus on water ecosystems originates from the recognition that global change can affect aquatic ecosystems and species directly as well as through changes in the surrounding landscape. To fulfill the mandates under the Clean Water Act (CWA), aquatic ecosystem research must understand what those effects will be.

The long-term goal (LTG) for the ecosystems research is to have decisionmakers use information and decision tools from the program to protect aquatic ecosystems by adapting to global change. The decisions that are being made and the information needs that those decisions imply form the foundation of the ecosystems LTG. Stakeholder needs supply the focus for the program's research and form the context in which all work is done. These needs determine the places that are investigated, the scale that is used, the types of ecosystem services that are analyzed, and, therefore, the design of the research. Outcomes result from the combination of understanding the decisions and conducting the assessments.

This approach was applied to the Sacramento River in California. Stakeholders identified the information needs on priority ecosystem services. A framework was developed to evaluate water supply for human consumption, irrigation, and Chinook salmon habitat. The stakeholders were interested not only in the results, but also in some of the tools that had been developed to assess the ecosystem in this area.

Dr. Julius noted that the strategic planning framework incorporated external scientific and stakeholder input, such as reports, U.S. National Assessment results, and expert workshops to determine focus areas within the ecosystems program. Based on this input, the program decided to concentrate on watershed and coral assessment, and biocriteria assessment. She described the bookends of those two research efforts as (1) problem formulation and approach, and (2) evaluation of the tool's usefulness. Projects are evaluated based on how well they accomplish or work toward the LTG.

Dr. Julius discussed several ongoing projects in the ecosystems focus area. In the South Florida watershed project, the goal is to determine the effect of climate change on Everglade restoration to inform planning decisions. Outcomes of this project include models and information currently being used in Community Environmental Resource Program (CERP) implementation plans to set performance measures for evaluating CERP impacts, choose species of concern, and formulate salinity targets for Biscayne Bay.

The American Samoa project includes work on corals. Currently, there is interest in why some coral reef areas have greater resiliency than others. The specific goal in this project is to assess the relative effects of climate change and interacting stressors on coral bleaching and recovery to aid in decisionmaking. EPA currently is meeting with members of the American Samoa government to provide recommendations based on the research. EPA hopes to link the research results with decisionmaking so the information can be incorporated in a meaningful way.

Dr. Julius discussed the program's work in biocriteria assessment. She explained that climate change can affect biocriteria directly or it can affect stressors, causing them to be more or less significant. Biocriteria managers may want to monitor for climate impacts and trends over time to understand how climate can affect biological criteria. Anticipated outcomes of the program include: (1) managers will understand the sensitivity of biological criteria, (2) managers will have the information they need to select appropriate biological criteria, and (3) new biocriteria programs will consider climate change.

Discussion of Air Quality and Ecosystems Posters
Global Change Research Subcommittee

Dr. Russell suggested that the afternoon session begin with a review and discussion of the air quality and ecosystems poster session. Dr. Reck led the discussion on the air quality poster session, and Dr. Coutant discussed the ecosystems poster session.

Dr. Reck remarked that she was very impressed with the morning presentations and with the posters. She noted that the poster descriptions were technically impressive, the ideas were sound and reasonable, and she commended the level of commitment, output, and application. The EPA staff seemed highly dedicated to the topics they represented. She praised the researchers who worked on *Global-to-Regional Information* for their management of the data-handling capacity, which was a particular challenge. She commented that part of the work being done within the Agency is to redo some of the modeling and report results in a much shorter timeframe, which requires an immense increase in data output.

Dr. Reck stated that she found the *Land Cover Impacts* study interesting because it enables scientists to make predictions on future emissions. The challenge will be to continue with robust predictions and extrapolations in that area. *Technology Implications for Regional Air Quality* raises the question of what new technology is on the horizon and how will it be most useful to the Agency. The researchers' efforts in this area and their attempt to unify the research into a reference frame for decisionmakers is important not only to EPA but to all research agencies and institutions.

The *Decision Support Tools* poster represents the ultimate anticipated outcome but involves most of the challenges and conflicts that researchers can encounter. Dr. Reck cautioned that, if support tools are being developed, researchers might favor one type of use over another, which could introduce political aspects of specific tools and thereby limit certain scientific applications. She asked what could be decided regionally. Resource allocations must depend on some type of decision support analysis. Dr. Reck commented that decision support tools, therefore, are the foundation of good decisions.

Dr. Coutant agreed with Dr. Reck about the quality of the posters and the enthusiasm of the staff. He commended them for the amount of information they were able to include on each poster. Dr. Coutant noted that the topics chosen to pursue are relevant for developing tools that will have broader applications. Making the connection between focus area topics and place-based topics and developing the most fruitful information from that connection were accomplished very successfully. Dr. Coutant added that, in a topic as broad as ecosystems, the way the subject is conceptualized is crucial for successful completion of goals. The posters and presentations demonstrate that much time has been spent considering how to conceptualize and develop the subject of global change and ecosystems.

Climate change can be viewed as changes that occur gradually over long periods of time (e.g., sea levels will rise by centimeters each century, and temperatures might rise by one or two degrees over the next 50 years). Dr. Coutant pointed out that many ecosystem changes are caused by sudden events, such as hurricanes. He suggested that Subcommittee members distinguish between episodic, catastrophic events and the more gradual-trend ecosystem changes. Dr. Russell noted that the consequences of incremental change are not always incremental. These changes can lead to massive short-term after-effects, particularly in unmanaged systems.

Dr. Russell asked Dr. Scheraga about the basis for selecting relevant issues to research. Dr. Sheraga explained that in 1998, the Agency, responding to a peer review, determined which of the program's activities were most consistent with EPA's mission and expertise, and the four

focus areas emerged (i.e., air quality, water quality, ecosystems, and human health). It was clear that the program could not focus on everything in each of those areas. The program looked for overlapping mandates and programs in other federal agencies. Eventually, a decision was made to integrate the program with the CCSP and other Agency programs.

The human health area was especially challenging. This is a very large area, and EPA does not have the resources to research this area extensively. The program has leveraged resources successfully and conducted joint solicitations with agencies, such as NOAA and NASA. Currently, there is a growing recognition that HHS, which should consider the effects of climate change, is not doing so. This is a problem for the program as it considers where EPA can have the biggest impact.

Dr. Russell remarked that EPA is motivating many researchers through STAR Requests for Applications (RFAs). He asked about the criteria for choosing an RFA topic. Dr. Scheraga replied that the program struggles with these questions, although recent efforts have been to move in the direction of decision support. Originally, the STAR projects were intended to develop assessment science and tools. Assessment is an ongoing process, and stakeholders can ask EPA to perform a rapid assessment at any time. The criteria for those RFAs included the ability to anticipate appropriate assessment techniques, tools, and models. Dr. Scheraga added that the LTGs are important determinants for the future direction of the program.

Dr. Coutant asked for more details about the RFA process, and Dr. Duke asked about the influence of past RFAs on the selection process and whether it is possible to study a topic sufficiently in 1 year. Dr. Julius explained that the program determines what is relevant and important to its research. Initially, RFA topics were based on information that EPA scientists considered necessary to their research. This process, however, has evolved over time. Several years ago, a national conference was held with ecosystem research experts to study the Strategic Plan and suggest the most important priorities for ecosystem research. Based on the results of this workshop, the ecosystem program set aside one active RFA and began to focus on the threshold area. Through this process, the STAR Program became a means of combining EPA and other federal resources and offering more in the threshold research area.

Dr. Bernice Smith explained that EPA uses resources, such as reports from the NRC and other expert bodies, to identify research gaps. She emphasized that EPA constantly seeks experts from inside and outside of the Agency to determine the most important science needs. The Research Coordination Team (RCT), which includes laboratory and center scientists as well as individuals from program offices and regions, discusses current inhouse research and opportunities to augment that research through the STAR Program. A writing team creates the RFA, which is announced to the public. A peer review process determines the most responsive applications. A relevance review process, made up of the RCT or other experts not initially involved in the planning process, takes place after the peer review. From this process, the most successful applicants are selected. The period of performance for most STAR grants is 3 to 4 years.

Dr. Grambsch added that the issues in the air quality area are slightly different. The air quality program can build on existing EPA expertise. The next step will be to discover where better science is needed most. In 2001, there was a workshop with air quality experts to determine key research needs. A list of recommendations was created and has been the basis for structuring many current RFAs. Another experts' workshop is planned for 2008, which will assess what has been learned and accomplished and will identify research gaps that still exist.

Dr. Grambsch noted that RFAs that are well written and well targeted solicit the best proposals. If proposals seem inappropriate, researchers should consider rewriting the RFA. The joint health solicitation involved several agencies, including NOAA, the National Science Foundation (NSF), NASA, and the Electric Power Research Institute (EPRI), and identified mutual interests. The basis of the RFA was to provide an operational tool that would be useful to the public health community and appeal to multiple communities while being multidisciplinary. The goal was to develop a tool that would address the linkage between climate and health impacts.

Dr. Russell asked about the requirements and criteria for decision support in terms of influencing the type of research that is done. How is the tension resolved between a mission-driven, decision-support program and a more science-driven program? Dr. Grambsch replied that the available expertise supports converting science into useful products and tools. The air quality area seeks to be the bridge between the science being developed and the decision-support tools. Dr. Wilkinson commented that both useful information and tools/methodologies are being provided for making decisions. Dr. Grambsch agreed and noted that incorporating the best information available into each tool is a goal in every area. Because scientists are close to the research in areas such as air quality, they are in a good position to achieve that goal.

Ms. Nierenberg asked if the program's experience with the regulatory side of EPA informed decision-support issues, such as critical areas of uncertainty and stakeholder interaction. Dr. Grambsch replied that the regulatory side does inform decision support. Dr. Balbus asked for a description of this interaction. Dr. Dan Laughlin explained that the program has worked extensively with the innovative strategies area in OAR, which develops regulatory impact assessments, because both groups have complementary goals, such as providing tools to in-house and regional decisionmakers to help evaluate different regulatory policies.

Dr. Coutant asked about assisting stakeholders, such as local power plant officials who want information about climate change scenarios. Dr. Tim Johnson replied that the program approaches the question of climate change scenarios and impacts on air quality using a multi-objective decision framework. In this case, several objectives would be considered, such as meeting the regulations for criteria pollutants and providing reliable electricity to customers. Climate change affects demands on power plants. For example, heat spells can cause an increase in air conditioning, which can require additional power and could necessitate the use of older, less efficient power plants that create more air pollution. Dr. Johnson explained that EPA constantly reviews such scenarios to provide broad support to stakeholders. Dr. Grambsch added that EPA uses MARKAL, the market allocation modeling tool, to analyze different technologies. Two sectors, transportation and energy production, are the current focus for this tool.

Dr. Scheraga explained that the ecosystem and air quality focus areas currently have more clients than they can serve with their limited resources, and this has led the program toward decision assessment activities. The decision inventory will help determine client and research priorities. Dr. Scheraga explained that developing and conducting research is an iterative process. Assessments provide the best scientific information available at the time, and analyses are conducted to inform decisionmakers. An important output from the assessment process is a research agenda, which identifies research gaps. The health science sector, for example, produced a long list of research gaps. Dr. Scheraga explained that, in theory, research gaps can be prioritized to determine which information has the highest value and to help direct specific research programs. He reminded the Subcommittee that EPA is a mission-oriented program and

not an exploratory program. The assessment activity is critical for determining the highest value of information from research activities.

Dr. Reck commented that EPA has fostered a cooperative environment among internal scientists, engineers, and other researchers; however, in the stakeholder area there seemed to be less cooperation and more competition. She asked about working with a group of stakeholders to determine the overall interests and needs of the group. Similarly, with the STAR Program, would it be more cost-effective to have one broad goal and award grants to the best of many different groups within this goal? Dr. Scheraga explained that competition refers to the awards process, not a competition among stakeholder groups. The program accomplishes Dr. Reck's suggestion to a great extent, within the resource limitations. The program does not have the resources to set up centers where stakeholder groups can be brought together on a regular basis. Within focus areas, the program has been successful at bringing diverse stakeholder groups, with competing objectives and different endpoints of concern, together in a deliberative process. In the regional assessments, the program has been very successful at building consortia between universities, which also are stakeholders, and between diverse stakeholders with competing objectives.

Dr. Julius added that stakeholder diversity and compatibility depends on the issue. The program has had experiences with cohesive groups of stakeholders with similar needs and other groups that promoted different agendas. The program has tried to work with appropriate stakeholders, whether they were compatible and homogenous or very different. In doing so, the need to learn more about stakeholder processes became quite apparent and has become a priority for the program. Much of what goes into understanding and working with stakeholders requires a fair degree of sophistication. It is important to understand their needs well enough to meet their needs, and the program has not reached that level of understanding. It is making progress, however, and has had several successes.

Program Relevance to EPA and the CCSP
Dr. Margaret Leinen, NSF

Dr. Michael Slimak introduced Dr. Margaret Leinen of the NSF. Dr. Leinen heads the Geosciences Directorate, one of six major operating units within the NSF, and serves as the NSF's principal representative to the CCSP. Dr. Leinen explained that today she is representing the CCSP, where she serves as Vice Chair, and that Dr. James Mahoney, CCSP Chair, sends his regrets. She will talk about the CCSP, how it has evolved, and EPA's role in the program.

The CCSP is concerned with basic scientific understanding about climate and global change. Its mission is to facilitate the creation as well as the application of the knowledge. It coordinates the federal agencies that either will undertake or sponsor these activities. There are 13 departments and agencies in the CCSP, and the current funding is approximately $2 billion per year.

The CCSP began as the USGCRP, which was formed in response to the Global Change Research Act of 1990. The USGCRP focused on identifying the knowledge gaps and uncertainties associated with understanding global change. In 2001, after an analysis of the U.S. position and the status of global change research, the Administration developed a new initiative, the Climate Change Research Initiative (CCRI), which began the transition to the new program. The CCRI focused on the human dimensions of climate change, improving modeling, and some of the important gaps in knowledge. Over the next year, the program worked among the agencies and

with the community to develop the CCSP Strategic Plan, which was released in 2003 and encompassed both CCRI and USGCRP and included input from stakeholders.

Goals and Core Approaches

The CCSP's goals are to:

- ✧ Improve knowledge of the earth's past and present climate and environment, including their natural variability, and improve understanding of the causes of observed variability and change.

- ✧ Improve quantification of the forces bringing about changes in the earth's climate and related systems.

- ✧ Reduce uncertainty in projections of how the earth's climate and related systems may change in the future.

- ✧ Understand the sensitivity and adaptability of different natural and managed ecosystems and human systems to climate and related global changes.

- ✧ Explore the uses and identify the limits of evolving knowledge to manage risks and opportunities related to climate variability and change.

The CCSP's core approaches include:

- ✧ Scientific Research: Plan, sponsor, and conduct research on climate and related systems.

- ✧ Observations: Enhance observations and data management systems to generate a comprehensive set of variables needed for climate-related research.

- ✧ Decision Support: Develop improved science-based resources to aid decisionmaking.

- ✧ Communications: Communicate results to domestic and international scientific and stakeholder communities, stressing openness and transparency.

Dr. Leinen added that decision support and communication are much stronger now than they were under the USGCRP.

Organizational Structure

The top level of the CCSP's organizational structure includes the White House, the Domestic Policy Council, the NRC, and the Council of Economic Advisors. The next level includes cabinet officers (i.e., administrators of the independent agencies) who meet regularly to discuss strategic planning, priority setting, and making the link to decisionmaking. The next level consists of agency and department deputies. The CCSP and the Climate Change Technology Program (CCTP) include representatives below the level of political appointees. The program, therefore, is linked to policymakers at the highest levels in the federal government and is connected closely to the CCTP.

Dr. James Mahoney chairs the CCSP Interagency Committee. Interagency working groups within the CCSP focus on numerous themes, such as atmospheric composition, carbon cycle, ecosystems, and several crosscutting themes, such as communications and international issues. Research priorities are determined annually, based on input from the working groups and agency priorities, and are consistent with the CCSP Strategic Plan. The budget is reported annually, and the program has begun a formal process of evaluating progress toward specific goals. Future evaluation will be informed by the NRC metrics report.

One of the CCSP's major accomplishments has been to develop the capacity of agencies and communities to address very challenging issues. This involves developing a community that understands the issues, has scientific credibility, and has the ability to address the problems. Dr. Leinen emphasized that developing research assets, such as the next generation of space-based and ground-based observing systems, is as important as achieving specific results.

Decision Support Resources Development

As part of the original USGCRP, Congress requested an assessment of the impacts of global change. The first assessment, published in 2001, was a monumental effort that tried to examine every aspect of the program and concentrated more on assessing the state of the progress than on actual assessment questions. Subsequently, the program has worked to establish scientific syntheses and assessments of difficult science questions. For example, the difference between time-series measurements of temperature in the upper and lower atmosphere has been a very challenging scientific problem. This is a question that must be resolved before assessments can be made concerning what these time series mean and whether the temperature of the atmosphere has changed over the last few decades. These types of questions need to be resolved, they are very complicated, they involve the way that measurements are taken and the type of models that are developed, and they require expertise from diverse sections of the scientific community.

There will be a total of 21 synthesis and assessment questions, which span all five CCSP goals and address such issues as the carbon cycle, land use, and risk in decisionmaking. This has been a major focus. These products will constitute the CCSP assessment effort as mandated in the 1990 Global Change Research Act.

EPA's Unique Contributions to CCSP

The CCSP has undergone a major change in direction, from conducting basic research to supporting decisionmaking and engaging decisionmakers. EPA, because of its efforts in decision support, is an important resource to the CCSP. EPA's work involves assessing the potential consequences and adaptation strategies associated with global change. Many other CCSP agencies partner with EPA. The CCSP Strategic plan, to which EPA contributed significantly, has an important role in framing those partnerships. EPA has a small percentage of the CCSP budget, but it has played a leadership role in several areas. It was a key player in the first U.S. National Assessment; it sponsored and led three regional assessments and the health assessment. EPA is the lead on three new synthesis and assessment products: sea level rise, adaptation options, and human health and welfare. EPA also is contributing to seven other CCSP projects.

EPA's Global Change Research Program: A View from EPA's OAR
Dr. Terry Keating, EPA, Office of Air and Radiation

Dr. Slimak thanked Dr. Leinen and commended Dr. Mahoney's extraordinary leadership. He introduced Dr. Terry Keating, Special Assistant in OAR, Office of Policy Analysis and Review. Dr. Keating is an expert in atmospheric chemistry and transport, whose work involves climate change, ultraviolet (UV) radiation, and transboundary air pollutants. Dr. Keating will speak about the relevance of the Global Change Research Program to OAR, which is a client of the program.

Dr. Keating began by describing the Global Change Research Program's role in the context of the other climate-related activities in EPA. Four major parts of the Agency are engaged in climate-related activities: OAR, ORD, the Office of International Affairs, and the regional offices.

The AA for OAR is the National Program Manager for climate change, and OAR is the Agency lead for all climate-related activities. OAR provides analytical support for policy development at the international, national, state, and local levels. OAR manages several voluntary mitigation programs, such as Climate Leaders, Energy Star, Methane to Markets, and many more. OAR is involved with technology development and leads the CCTP, the counterpart to the CCSP. The Office of Transportation and Air Quality is involved with developing alternative motor vehicle technology. OAR also is involved with international capacity building.

ORD's Global Change Research Program is the Agency lead for the CCSP. It assesses impacts to air, water, ecosystems, and health, and develops decision-support tools. The Office of International Affairs works closely with OAR in capacity building on the international level. This work emphasizes multiple benefits, both at the local level and the international level. The regional offices are involved with supporting voluntary programs and state and local activities.

The traditional issues for OAR include:

- ✧ Revision and implementation of the National Ambient Air Quality Standards (NAAQS)
- ✧ Hazardous air pollutants (i.e., air toxics)
- ✧ Motor vehicle and fuel standards
- ✧ Acidifying deposition
- ✧ Visibility
- ✧ Climate change policy
- ✧ Stratosphere ozone protection
- ✧ Radiation and indoor air quality.

There is significant interaction between these issues and three major issues in the Global Change Research Program: (1) climate change and variability, (2) implications of global development, and (3) UV radiation. Most of this interaction is related to ozone and fine particles, motor vehicles and fuel standards, climate change policy, and stratospheric ozone protection, and it is particularly important in the air quality assessment.

The air quality assessment fills a vital niche in the CCSP in two respects: (1) it focuses on the consequences of global change for air quality managers, and (2) it connects global change to local health and control investment implications. For the science to be useful, decisionmakers must perceive global change impacts as real. The issues must be translated into terms that are associated with their decisionmaking. OAR has emphasized this concept with colleagues in ORD, who have been very responsive in applying it to the design of the air quality assessment.

The Global Change Research Program has included OAR in the design of the air quality assessment. The offices have worked together on the selection of tools, methods, and timeframes. In the future, it will be necessary to shift from a focus on the assessment methods to the results of the assessments and how they will be communicated to stakeholders. The air quality assessment also produces tools, methods, and information that apply to many other OAR efforts, and many of the Global Change Research Program's activities complement OAR's work. For example, OAR is examining the impact of air quality on climate change, while the Global Change Research Program is studying the impact of climate change on air quality. Other complementary areas include:

- ✧ Intercontinental flows of air pollutants
- ✧ Public information programs related to climate change
- ✧ Integrated analysis tools for air quality management
- ✧ Alternative motor vehicle technology development
- ✧ Future technology and emissions scenario development
- ✧ Biogenic and wildfire emissions estimation
- ✧ Global integrated assessment modeling.

UV research falls under the umbrella of the Global Change Research Program. From 1994 to 2004, the program ran a nationwide UV monitoring network, comprised of 21 spectrophotometers in national parks and urban sites across the country. In 2004, the decision was made to end this program. Dr. Keating described this decision as a classic story of monitoring programs. The program began with a particular design and sufficient funding. With increasing budget pressures over time, the funding decreased. As the funds diminished, OAR argued to keep all 21 sites operational. Consequently, resources were shifted into site operations, until no money was left for analysis. The program collected a great deal of information that was not being used. Finally, as management continued to reduce the budget, it was determined that very little was being learned from the monitoring network. Consequently, the program was cut.

Meanwhile, an interesting policy driver was thrust upon OAR. As part of the litigation over a 1997 legal case, the court instructed OAR to balance the beneficial effects of tropospheric pollutants (i.e., shielding UV radiation) with the negative effects. In its remand to the court in 2002, OAR agreed to do so, but it explained that there was insufficient information to relate changes in tropospheric pollution to changes in surface UV radiation. It was decided that the research would continue and the results would be incorporated into the decisionmaking process. This created a policy problem. The program agreed to continue the research, but the only program providing that information had been cut. As a stopgap measure, OAR and the Global Change Research Program are sponsoring a 3-year program to study the relationship between tropospheric pollution and surface UV levels. This consists of redeploying monitoring at six sites in collaboration with NOAA and issuing STAR grants for data analysis. After the 3-year commitment, there is no funding for further research in this area. Dr. Keating noted that he welcomed input from the Subcommittee about continuing this research, both within OAR and ORD. Dr. Coutant commented that there is a significant need to advise judicial decisionmakers as well as the executive and legislative branches of government.

Relevance of the Global Change Research Program to EPA Regional Offices
David Ullrich, Great Lakes and St. Lawrence Cities Initiative

Dr. Scheraga introduced Mr. David Ullrich, a 30-year veteran of EPA and former Deputy Regional Administrator and Acting Regional Administrator for Region 5. Mr. Ullrich has been involved with the U.S./Canada International Joint Commission and was the co-chair of its Water Quality Board. He is now Director of the Great Lakes and St. Lawrence Cities Initiative. Dr. Scheraga explained that the regional offices are major clients for the Global Change Research Program, and are close to the decisionmakers, so they serve as a critical interface between the decisionmakers and the program.

Mr. Ullrich thanked Dr. Scheraga. In reference to Dr. Coutant's comment, Mr. Ullrich explained that it is possible to educate judges. In Region 5, a successful training program was initiated to inform municipal judges about the health hazards of illegal dumping, an issue that the judges had not considered to be serious. Mr. Ullrich stressed the importance of building links between scientists and those who need scientific information. He noted that he had worked for EPA for 5 years before becoming aware of ORD. Mr. Ullrich emphasized that climate change is a real concern for mayors and other local decisionmakers. He recommended that EPA make an effort to interact personally with stakeholders to inform them of the research and information that is available. He added that mayors generally do not read scientific journals, and most are not aware of ORD and what it does.

Mr. Ullrich stated that his EPA experience includes 3 years in the water program, 6 years in the air program, and 6 years managing more than 100 lawyers. He managed the hazardous waste program and worked in the area of pesticides and toxics. He also served as the Acting Regional Administrator for several years.

As Director of the Great Lakes and St. Lawrence Cities Initiative, Mr. Ullrich represents these cities at many decisionmaking opportunities. He conveys a sense of the mayors' urgency and practicality in their approach to decisionmaking. Further, his interaction with stakeholders provides an understanding of which issues need to be addressed. Mr. Ullrich explained that the Global Change Research Program is important to his organization because climate affects people's lives. For example, in 1995, there were more than 500 heat-related deaths in Chicago. Mayors need to know about these issues; they make decisions based on a broad range of information, without having the precise details. Mr. Ullrich added that mayors lose elections on such issues as plowing snow. Major rainfall events affect beach closures and drinking water quality, and decisions about building construction require climate change information.

Mr. Ullrich commended Dr. Scheraga for speaking to state directors and other local stakeholders about climate change issues. He added that the program has been beneficial for state directors, mayors, the International Joint Commission, foundations, and nongovernmental organizations. He noted that 50 mayors recently signed onto the Kyoto Protocol. Mr. Ullrich commented that other such actions are likely to occur in a wide range of issues. In terms of outputs and outcomes, Mr. Ullrich stressed direct contact with local decisionmakers in language that they understand. He added that policymakers and implementers need to understand the constraints under which the program operates, and the program needs to understand their constraints as well.

Mr. Ullrich mentioned several issues of concern to stakeholders. Regions and communities need to know about potential frequency and intensity of precipitation events. Over the next 20 years, the cities on the Great Lakes will have to solve the problem of combined sewer overflow. They will make multimillion-dollar decisions on how big the pipe diameters should be, and they cannot wait for the perfect science to make these decisions. Judgments have to be made using

the best information available. Mr. Ullrich stressed that many of these decisions currently are based on old documents and not on the best science that is available. He added that Lake Erie is experiencing an increase in the size and duration of the dead zone. The cause is uncertain, but it appears to be a combination of various invasive species, phosphorus, and temperature change. There are many additional issues that are of great importance to the regions. He stressed that the program's work is very relevant and important to people, and he emphasized the value of personal interaction.

Dr. Wilkinson asked to what extent decisionmakers are interested in information that goes beyond adaptation, such as mitigation strategies. Mr. Ullrich replied that they are extremely interested. Issues are driven by practicality, and mayors believe that they cannot rely on one strategy, such as an adaptation strategy, but that they need to work proactively on mitigation as well. He reiterated the 50 cities that have made Kyoto-type commitments to reduce emissions. Mayors can serve an important function of educating their communities and can lead by example. Many cities are buying fleets of hybrid vehicles, for example.

Dr. Russell commented that Mr. Ullrich described many long-term, capital-intense, long lead-time types of decisions. Infrastructure decisions are key for mayors and localities, and these also are the most susceptible to the effects of global change. It might be difficult to communicate the value of these investments to taxpayers. Mr. Ullrich replied that infrastructure is critical to the well being of cities and to mayors' careers. He added that taxpayers are becoming more receptive to these investments. For example, taxpayers in Toledo voted, by a 70 percent margin, for a rate increase to cover a $400 million investment in sewer system improvements that reduce raw sewage releases. He added that the public is farther along than we realize.

Subcommittee Work Session
Global Change Research Subcommittee

Ms. Nierenberg commended the Global Change Research Program for its capacity to grow and adapt, its effective use of ORD laboratories and the STAR Program, and its excellent staff. She asked Dr. Scheraga about how decisions are made and about the health announcement. Dr. Scheraga explained that there has been a dramatic change within ORD in the last year in the way it manages and allocates its resources across laboratories, as well as intramurally and extramurally. This year, beginning with the departure of Dr. Paul Gilman, who was the AA, and continuing under Mr. Tim Oppelt, who currently is the Acting AA, NPDs were established for all of the major ORD programs. Before the NPDs were established, the programs were matrix-managed, and budget decisions were made by consensus. Now, however, the NPDs have some budget authority and can make programmatic recommendations about reallocations of resources and FTEs. The health announcement is a good example of this. This was a joint solicitation with NOAA and other organizations for several years. The resources for that solicitation came from one of the centers and, prior to the establishment of the NPDs, the director made a unilateral decision that this was not the right mechanism for funding health research. The program was forced to withdraw from the joint solicitation, but the programmatic need still existed. Dr. Scheraga explained that when he became the NPD, he looked for other mechanisms to fund this work. The other agencies had backed away; consequently, the program issued two RFAs to pursue research gaps and decision support.

Dr. Slimak added that it is important for the Subcommittee to recognize that the program has established a coordinated and integrated program, but it has not been without pain. The program

has had to withdraw from certain research areas, including a great deal of terrestrial ecosystem work that was conducted at the Corvallis Laboratory. Part of the decision was to allocate some of those resources to the health assessment area because it was thought that EPA could have a significant influence across federal agencies, but it was a very difficult decision.

Dr. Scheraga added that the program is interdisciplinary and integrated across expertise. All of the programs cut across the "stovepipes" of the laboratories and centers. Dr. Gilman recognized that there were no incentives for reallocating the budgets when those decisions were made by the stovepipes and disciplines themselves, so he established NPDs to manage programs that span across laboratories and centers. Dr. Balbus commented that this is an important point to add to the wisdom chapter. He noted that the program's integration has been remarkable and that the coordination and use of the STAR Program and the intramural work has been exemplary. He asked for a written description of the decision to implement NPDs if it were available.

Dr. Russell asked about incentives for supporting long-term, high-cost, low-probability/high-consequence decisions. Dr. Scheraga described six types of incentives. The first incentive is from OMB. Under this Administration, there has been increasing emphasis on justifying programs based upon quantifying outcomes. The PART exercise, which is used every year in the President's budget requests, has been an economic incentive and a painful process. Second, during a period of declining budgets, there is an increasing push from EPA to have ORD justify its expenditures in terms of outcomes that are meaningful to the client offices. The third incentive is leadership. Dr. Scheraga commended Drs. Gilman, Noonan, and Farland, who have recognized that in a mission-oriented agency, it is incumbent on the program to build scientific foundations and to provide timely and useful information to the rest of EPA. The fourth incentive comes from the NPDs, who have programmatic or policy experience and understand customer needs. The fifth incentive is the CCSP, which is very important in sustaining the program and forcing changes. The CCSP's change from assessment to decision support, concurrent with this program's evolution, has been very helpful. OMB also evaluates the program's responsiveness to CCSP. The sixth incentive is the NRC. Its recommendations have had a very big impact. Dr. Slimak added that there are many Dave Ullrich-type stakeholders. They have been found in every region and are coming to the fore, asking questions about the impact of climate change on the decisions they have to make; this is a very important driver.

Dr. Wilkinson noted that there is a great deal of connection and overlap in the ecosystem work, and stressed the value of presenting a more holistic view of the research. For example, inexpensive air conditioners were purchased in Chicago to help people during the heat wave. Although this was helpful in the short term, air conditioning exacerbates the greenhouse gas emission problem. Longer-term urban heat island strategies, on the other hand, help both in the short and long term. He commented that the program's total work is much richer than individual projects might indicate.

Dr. Scheraga agreed and added that it is important to identify those opportunities. The issue involves the processes for conducting work as well as the program's organization around focus areas and place-based work. He explained that, 10 years ago, all of the work was done at the national level. The science revealed that there is a regional texture to climate and to the consequences of climate change. That led to the first U.S. National Assessment, where regional assessments were conducted to capture the regional texture. Within regions there is a local texture, and many local and community-based issues emerged from those regional assessments. Much of the program's work in the focus areas and the regional assessments was place-based,

and the geographic scale was determined by the clients. When it was recognized that decisions about geographic scale were determining the issues on which to focus, a decision was made to reverse that approach. The program now is using decision analysis to identify appropriate issues to pursue, by considering what local decisionmakers deem important, the extent to which they care about these co-benefit issues, and where the program can provide the greatest value. From there, the geographic scale and particular issues can be determined. In this way, more of the co-benefit opportunities will be captured. Dr. Grambsch added that decision analysis will include consideration of work that either can be accomplished by the program or started by the program and completed more effectively elsewhere (e.g., urban heat islands). Dr. Coutant noted that other national programs are deliberating the distinction between site-specific and generic work, which often is a communication issue.

Dr. Russell remarked that the concept of starting with decisions and moving to the science is missing in the written materials. Projects seem to be driven by the science and the scientists rather than the value of decisions they support. He asked about an underlying framework for determining what issues are important to pursue. Dr. Scheraga explained that the program is working on stakeholder processes to identify the decisions up front and then to keep the decisionmakers involved throughout the assessment processes. It has been very humbling to realize that stakeholder engagement is a science unto itself, and the program needs to learn more about it. The focus areas have invested in activities that were built around relevant decisions. The issue now is to determine the right issues to address among the many possibilities.

Dr. Russell asked about the criteria for determining the right decisions. Dr. Julius explained that priorities for the ecosystem focus area include: areas that are sensitive to climate, ecosystem services that are important to society, areas in which there are existing data on which to build, and areas with stakeholder groups to which the program has some access. The program is working toward a more systematic approach. It needs to determine whether the work can be generalized and transferred to other areas. In the beginning, the process was informal, but it is becoming more formalized as more people make demands and resources become more limited. Dr. Slimak commented that the Subcommittee has raised an important issue. The program is beginning work on a decision inventory; however, more investment in the science of decision support means less investment in other areas. This work also calls upon the social sciences, for which ORD has limited resources, although it is beginning to acquire these skills. The program welcomes advice from the Subcommittee on this issue of decision support.

Dr. Wilkinson noted that some strategies have value currently and will have expanded value in the future under different circumstances. There seem to be important connections between the global-level research and every-day decisions, which could be enhanced by integrating with other activities to maximize the investment (e.g., storm water sizes can be reduced if they are linked to a watershed strategy that also has water quality benefits, flood control benefits, and more). Dr. Wilkinson asked how to get economic numbers to help explain the value and inform the decisionmaking process. He added that there are substantial resources at the state and local levels that will be spent on strategies for flood control, water supply, and other issues.

Dr. Scheraga replied that these are difficult issues, which warrant much discussion and research. He commented that not everything has to be monetized to assess the value of the information or to help decisionmakers. The program has worked on multi-attribute approaches to help decisionmakers organize the information, identify decisionmaking criteria, and rank different strategies in which they might invest. The NRC metrics report was very effective at identifying

types of outcomes from research and assessment programs, aside from a cost/benefit analysis. Dr. Wilkinson replied that some investments have many benefits that can be quantified, but they generally are not packaged in a way that demonstrates the numerous additional benefits in other areas. A more comprehensive, holistic view would provide a better understanding of the total value.

Dr. Slimak mentioned a study conducted in New Orleans (prior to the recent hurricanes) in which two-thirds of voters indicated that they would rather invest in wetlands restoration than levee construction to control flooding. The study estimated the costs for each strategy to be about equal. Dr. Russell replied that they would be in favor of wetland restoration rather than building levees, but the problem is that the federal government pays to build levees whereas wetlands restoration requires that the region gives up its land, which will not be available for other uses. When talking about decision support, the issue is not about broad generalities and abstractions, it is about how to make decisions about problems in which individual incentives differ and the decision must be collective, as in the case of levees versus wetlands. That is the type of issue that is relevant and important for the program to pursue as opposed to an issue that is nice to know but will not make any difference to society and the future.

Dr. Duke added that this is why it is important to include the social sciences. That kind of knowledge comes from the social sciences, and other BOSC program reviews have recognized that as well. Dr. Scheraga noted that he and several others in the program have backgrounds in economics. Dr. Grambsch added that the program leverages resources from other parts of ORD and EPA. In a recently released strategy on environmental evaluation, ecological evaluation was at the top of the list along with health benefits evaluation. The program works with the National Center for Environmental Research (NCER) to issue RFAs. The program also works with the National Center for Environmental Economics in the Office of Policy, Economics, and Innovation, where a cadre of economists works on evaluation.

Dr. Coutant asked if there was resistance from other groups within EPA. Dr. Scheraga replied that communication can be difficult between different parts of the Agency, but that a long-term investment should be made to facilitate such a dialog. He explained that in many areas within EPA, climate change is not seen as a process that has been ongoing for millions of years, but is considered to be an event that either will not occur or will occur many decades in the future. These offices are overworked with immediate concerns and do not want to address issues that they perceive as irrelevant.

Dr. Scheraga mentioned one additional economic incentive. In the most recent budget process, the Administration removed 20 percent of the budget and set it aside for a pilot program, in which ORD and other program offices had to compete for resources. The purpose was to encourage ORD to focus on short-term, timely issues of concern to the program offices and to push the program more in the direction of decision support. Congress rescinded that program, but it sent a very strong signal to ORD about the Administration's thinking.

Dr. Russell thanked the participants and adjourned Day 1 of the meeting.

TUESDAY, SEPTEMBER 27
Dr. Milton Russell, Chair, Global Change Subcommittee

Dr. Russell reviewed the previous day's activities and discussed the day's agenda, which included presentations on water quality, human health, and place-based assessments; a poster session followed by a question and answer period; time for public comments; and a Subcommittee work session. Dr. Russell thanked the EPA staff for their excellent and informative presentations.

Water Quality
Dr. John Furlow, EPA, ORD

Dr. Furlow began his presentation by explaining the choice to focus on water quality rather than water quantity or other issues. In 1999 and 2000, when the program's Research Strategy was being written, several sector assessments from the U.S. National Assessment were released. The water sector assessment focused on numerous water-related issues, but it did not address water quality. This implied either a research gap or a lack of significance. The need to address water quality was confirmed when the health sector assessment indicated that climate variables could be related to drinking water-borne disease. Water quality supports EPA's mission and its Safe Drinking Water Act (SDWA) and CWA responsibilities. The focus on quality also allowed EPA to fill a niche within the USGCRP, which now is the CCSP. Other agencies within the CCSP focus on different aspects of the water cycle and water supply, but EPA took the lead in water quality. EPA shares the lead with NOAA on decision support in the water cycle group.

Dr. Furlow explained that climate change affects precipitation patterns and, as water runs across different landscapes, it alters pollutant loadings in source waters. Consequently, stream flow and receiving water quality may change. The question that has guided the program is, as climate changes, will communities still be able to provide clean, safe water. The LTG in this area is that decisionmakers will use information and tools from the program to protect water quality by adapting to global change.
The water quality focus area primarily has examined source water and receiving water, including: (1) impacts to source water and subsequent effects on drinking water treatment, and (2) impacts on receiving water quality and potential effects on wastewater treatment. The program is beginning to examine nonpoint source runoff, urban runoff, combined sewer systems, and combined sewer overflows. Dr. Furlow explained that, within that narrow focus, there still is a broad range of issues that could be examined. He described the considerations for selecting projects, given the program's limited resources, people, and time. Projects must be consistent with EPA's mission, and projects that will have a large impact are preferred. The program examined costly, long-term, irreversible decisions, which led to decisions associated with infrastructure projects and major rules. The program also is beginning to explore alternatives to infrastructure options. Other considerations include sensitivity to climate variability and change and opportunities to influence a decision. This involves working with stakeholders to understand the decisions they are making and the inputs needed for those decisions.

The water focus area's clients include the other focus areas, OW and other EPA program offices, and several regional offices and municipal water departments. Some work has begun with the Smart Growth group, and a project is underway that will lead to work with the Green Building Council.

As projects were developed, milestones were established, which fell into categories of drinking water, wastewater, and adaptation options. As milestones are achieved, lessons are learned and

new research opportunities arise. Currently, there are milestones for drinking water in 2005, wastewater in 2006, and adaptation in 2008-2009.

In the area of drinking water, the program asked: (1) As source water quality changes, will we be able to continue to treat the water and provide safe water to communities? and (2) Do coastal communities rely on intakes that are vulnerable to sea level rise? To date, the program's research has concluded that the country is in fairly good shape nationally; however, for those in communities that are vulnerable to sea level rise or that have problems meeting their drinking water standards, the problems are acute.

In the wastewater area, the program is examining decreases in low stream flows and determining whether or not the effects of those decreases will impact the requirements on wastewater dischargers. The program also is examining how climate change might exacerbate the low flows and, consequently, affect the requirements on wastewater treatment plants.

The program also has examined how changes in precipitation patterns might impact the long-term control plans that communities are developing and implementing to reduce the number of combined sewer overflows. Most communities base these plans on historical weather data patterns; but, if the weather changes, they could over- or under-adapt. In the Great Lakes region, the program studied potential changes in precipitation patterns and their effects on long-term control plans. Initial results have been received and will be shared with community managers. This interaction will help determine how such information can contribute to community planning. This study also found that it is important to understand how regulators might act on a rule if they interpret it very strictly. The community might respond differently if a more lax approach is taken.

In the next few years, the program will begin studying nonpoint sources of pollution, including pollutant loadings in estuaries, as climate and land use change. The program is beginning to distinguish between the consequences of climate change and land-use change. It will examine adaptation options to address urban runoff (e.g., rain gardens, bioswales, green roofs, and other options that might reduce the pressure on traditional storm water and wastewater treatment systems). The program is beginning to develop tools to assess the effectiveness of various management options associated with such issues as agricultural runoff and water quality at the watershed scale. These products help build links to the aquatic ecosystems program. Although the focus areas are described somewhat distinctly, there is much communication between the groups, and some researchers work in both areas. Dr. Furlow added that the water quality focus area is a small group that is working hard to accomplish its goals, and he thanked the team.

Ms. Nierenberg asked if the team included external researchers. Dr. Furlow replied that most of the work has been done inhouse, but some of the STAR work and some of the regional assessments have included water projects. Dr. Balbus asked about stakeholder involvement outside of the regional assessments. Dr. Furlow replied that, in the combined sewer system project, the program is working with managers in New England, whose feedback about long-term control plans was used in a control study. In 2006, a workshop will be held to present results of the study and to learn what that information means to the managers, how they might use it, and what additional information they might need. There was definite interest in climate change, but they did not understand what they could do with the information. This interaction started with calls to the combined sewer overflow manager at the EPA regional office to request contacts in local communities. After reaching these managers and working informally, the

program will continue to work in a more formal way. This has been the pattern in other areas as well.

Dr. Russell noted that the endpoints of concern seemed to be primarily human health rather than ecological or unmanaged systems. Dr. Furlow confirmed that the program focuses primarily on the human health endpoints that are described in SDWA, but this is not a human health program; it addresses drinking water infrastructure in the face of weather changes, and the endpoints under SDWA are health based.

Human Health
Dr. Joel Scheraga, EPA, ORD

Dr. Scheraga explained that he was presenting in place of Dr. Gamble who, as DFO, is not permitted to participate in the technical discussion. The health focus area funds only two FTEs, Dr. Gamble in full and Drs. Scheraga and Grambsch in part. Dr. Scheraga will discuss why the program includes a health focus, its activities, and its outcomes.

Why Have a Human Health Focus Area?

The first reason to include a health focus is scientific. The link between climate, climate change, and human health has been recognized for more than 10 years. Temperature, precipitation, and extreme weather events have important health consequences, some more direct than others. Heat stress, for example, affects health directly. Some of the more complex and least understood impacts include those that are mediated through ecosystems. Science does not understand the ecological changes that are occurring that can cause problems, such as vector-borne diseases.

The focus on human health is consistent with EPA's mission to protect human health as dictated through the CWA and the SDWA. ORD researchers, outside of this program as well as within, have expertise in such issues as the health impacts from contaminated water and health impacts from air quality. The program has little in-house expertise in certain areas, such as vector-borne disease. That expertise is leveraged through the STAR Program. Dr. Scheraga emphasized that clients, such as OAR, are interested in the health focus area. As climate change affects air quality, it will have direct and indirect effects on human health. This focus also is consistent with the CCSP Strategic Plan. The program's LTG is to provide decisionmakers in EPA's program offices and regional offices with scientific information they can use to protect human health by adapting to global change. The program's four focus areas originated from recommendations in the first U.S. National Assessment's health sector assessment.

Activities

Dr. Scheraga explained that the program has invested in three different types of activities in the health area. The first type is needs assessment—identifying research needs and knowledge gaps. Many research gaps are identified through stakeholder-driven assessment processes, which help ensure that the research targets issues that are important to clients. The second type of activity is health impacts research—developing quantitative estimates of the health risks associated with climate change. Most of the program's efforts go toward this area. Opportunities also exist in this area to work with other CCSP agencies, which is important because of the cost of conducting health impacts research and the small size of these programs. The third category is

the assessment work—developing information about potential adaptation strategies and decision support.

The first needs assessment was the 2001 health sector assessment. The key conclusion was that levels of uncertainty in the health area are more extensive than in any of the other focus areas. Thirty categories of knowledge gaps were identified. The challenge is to prioritize those gaps. A recent report concluded that significant levels of uncertainty still exist. Health outcomes that are important to the country have been a focus of epidemiological study in the United States for many years, and large investments are necessary to advance this work. There also are significant data gaps that limit the extent to which the science and the assessments can advance at this time. Dr. Scheraga stressed that the impacts of climate change on human health will remain uncertain until reliable estimates of impacts and adaptive capacity are developed.

Between 2000 and 2003, the primary health assessment activity was conducted through an interagency joint solicitation. Most of these grants were associated with vector-borne and water-borne diseases, where EPA has little expertise. Two STAR RFAs were awarded. The first RFA focused on two priority research gaps, heat- and cold-related illnesses and water-borne diseases. The second RFA focused on decision support (i.e., identifying the types of information required to help public health decisionmakers). One jointly sponsored study examined the relationship between El Niño effects and outbreaks of Bartonellosis. Dr. Gamble and her collaborators also are conducting a variety of assessment and adaptation/decision activities.

Accomplishments

One of the program's significant outcomes is an ongoing collaboration with NASA, the Centers for Disease Control and Prevention (CDC), Johns Hopkins University, and public health officials in the Southwest. This effort has produced real-time risk maps that examine ecological changes and changes in land cover to predict the risk of hantavirus exposures.

The program has made significant contributions internationally. In 2001, a peer review recommended that EPA recognize the global implications of climate change. These are particularly relevant in the area of human health because modern international transportation enables diseases to spread very quickly. The program has partnered with organizations such as the World Health Organization (WHO) to further capacity building. EPA sponsored the WHO's first book on climate change and human health, and produced an updated version in 2003. The Agency has worked with the WHO to develop assessment methodologies that are shared with developing countries. This year, in partnership with EPRI, the program produced a book on lessons learned and insights for adaptation policy, which is useful for decisionmakers nationally and internationally. EPA also is working with the WHO and NOAA to sponsor capacity-building workshops around the world and contribute to other processes, such as the Millennium Ecosystem Assessment, to capture the linkages between ecological change and human health.

The program is working with OAR's outreach and communication groups to help cities develop heat response plans. These groups also are translating the program's research results into readily accessible information for the public.

Future Directions

Most of the health impacts research will continue through STAR RFAs. The program will use the decision assessment activity to identify important stakeholders in the public health community and to prioritize future program directions. Dr. Scheraga added that the program will continue to work with the rest of the CCSP to engage HHS.

Place-Based Assessment Issues
Dr. Michael Slimak, EPA, ORD

Dr. Slimak described the integration of the regional assessments (place-based work) with the work in the focus areas (issue-based work). In issue-based work, the issue determines the problem to be addressed. For example, in the human health focus area, problems were identified, which led to an assessment of water-related morbidity and vector-borne diseases. In the regional assessments, the place determines the issues to be assessed, and local stakeholders usually make these determinations. There also is a place-based nature to the work that has been identified in the focus areas, especially in water quality and ecosystems. STAR solicitations often use a place-based approach to assessing multiple stressors and climate change. Over the past few years, more than 22 STAR grants, representing approximately $15 million, have been awarded that are place-based in their approach.

EPA decided to invest in regional assessments for several reasons. First, the consequences of global change will have a regional texture, (e.g., sea level rise along the Southeast and Gulf Coasts, or warmer nighttime temperatures in the Great Lakes region). The first U.S. National Assessment used both a sector-based and a region-based approach. EPA sponsored assessments for three regions: the Great Lakes, the Chesapeake Bay, and the Gulf of Mexico. These three biogeographical provinces represent a range of climate change impacts as well as opportunities for adapting to climate change. There also was a recognition that any political support associated with climate change would require engaging the lay public and affected stakeholders. Most importantly, EPA invested in regional assessments because, with the lag effect of greenhouse gases, CO_2 levels will continue to rise, and global warming will be an inevitable consequence. Many climate science leaders have asked about the regions' ability to adapt to climate change and the nature of the decisions that regional and local stakeholders would face.

The first U.S. National Assessment focused on sectors, such as human health, agriculture, and forestry, and on 19 geographic regions. As noted above, EPA sponsored three of these regions and the health sector. In this case, sponsorship meant the funding of a cooperative agreement with universities located in those regions. The universities would have stake in the outcome and begin to build an educational and research infrastructure that would continue into the future.

At EPA, regional assessments are thought of in phases. Phase I began with the first U.S. National Assessment in 1998. The regional assessments were asked to determine potential affects of climate change and variability in the context of other stressors. The endpoints of concern were determined by the stated needs of the stakeholders. Each assessment was conducted by a federal agency/university partnership, but the final assessment was prepared by the university and given to a federal advisory committee, known as the National Assessment Synthesis Team. Although the Phase I assessments used identical climate change scenarios, the consequences were different depending on the region and the stakeholders' interests.

Phase II currently is underway. EPA and the other agencies were encouraged by the enthusiasm and the commitment shown by the university partners and stakeholders. It is not clear whether

another U.S. National Assessment will be conducted, but because of EPA's success with the three assessments, regional assessments became a major component of the CCSP, and the Global Change Research Program committed to a second phase of region-scale assessments in those regions. University partners were selected through an open competition. They were asked to continue working with stakeholders on an iterative basis and focus on decision-support tools that the stakeholders might use in adapting to climate change. In Phase II, the successful proposals were submitted by university consortia, because no one institution could cover an entire region effectively.

Dr. Slimak noted several highlights. For the Gulf Coast Phase II work, the consortium is led by Texas A&M University. It is analyzing the way decisions are made and the importance of scientific information to the stakeholders living along the Gulf Coast. The study team includes researchers and stakeholders in the fields of climatology, sociology, political science, environmental science, planning, and geography. Part of that study involves adaptation strategies for hurricanes. Last year, a model scenario predicted the effects of a major hurricane in the Gulf Coast; the maps of predicted flooding were accurate to within two blocks of the recent flooding in that region.

Michigan State University is leading the Great Lakes assessment, which focuses on the design and use of tools for decisionmaking. Rather than organizing by locations, the study examines the outdoor tourism and tart cherry agriculture sectors. For tart cherry growers, a model is being developed that links climate, agriculture, and financial relationships. For the tourism sector, planning tools are being developed to enable businesses in Michigan to examine historical and future climate patterns and the effect on outdoor recreation. Michigan State University established a permanent climate science program within the school.

The regional assessments have produced a body of work that represents important outputs, including journal publications, technical presentations, development of tools, education of graduate students in climate science, and the development of courses in the consequences of climate change. Outcomes, such as the creation of the departmental program in climate science, the use of decision tools, and the availability of climate information to affected stakeholders, provide further evidence that the commitment to regional assessments is producing its intended benefits.

Dr. Slimak explained that the engagement of affected stakeholders is critical if communities are to adapt to climate change or marshal any lay public support for mitigation. As a research organization, ORD's advancement in the science of conducting regional-scale assessments is noteworthy. Ultimately, assessment methods must be translated into decision-support tools that are relevant to the stakeholders, and those tools will have to be used with a high degree of confidence.

Dr. Slimak summarized by stating that regional assessments are an effective way to integrate the program, and they are an important component of ORD's programs. These types of assessments are consistent with the CCSP Strategic Plan, and this approach is supported strongly by the NAS. The work has advanced the state-of-the-science and led to important outputs and outcomes. It is the most effective way to connect with the lay public, which is the ultimate client for this type of research.

As the Phase II work concludes, the program is evaluating its next steps. Should there be a third phase and, if so, should it remain in the three locations in which EPA has invested and continue to refine the decision-support tools? The program currently is initiating a study of EPA regional and program offices that will evaluate the types of decisions they make and whether these decisions have a climate change component. This study will help guide the program's choices. There also are important questions of scale, both temporal and spatial. Although there is strong support for regional assessments, this type of work has waned among the CCSP agencies. The feedback from this program review will help guide the future of this research.

Discussion of the Poster Session and the Presentations
Global Change Research Subcommittee

Dr. Russell introduced a general discussion of the morning's poster sessions and presentations. Each Subcommittee member led a discussion of the focus area for which he or she was responsible in the report.

Water Quality

Dr. Wilkinson began with the water quality poster that addressed future directions. He asked about integrating issues, such as riparian buffer strategies, nonpoint source pollution, opportunities and problems with estuaries, and the green infrastructure/land use connection, as well as water quality benefits in the health and ecosystem focus areas. Dr. Furlow replied that the health focus area has been small, but he hoped that the program's accomplishments in drinking water infrastructure could be used in research on water-borne disease. Some studies are searching for a correlation between weather extremes and water-borne disease outbreaks. This program is addressing the missing piece (i.e., whether the problem occurred at the drinking water plant). This work is ongoing, and more effective ways to address the problem are being considered. The program also recognizes that ecosystem and water quality research overlap in many areas.

Dr. Wilkinson explained that understanding the "soft" approaches, such as riparian buffer strategies and green infrastructure, is important for communities across the country that are facing long-term, capital-intensive, potentially irreversible infrastructure investments. He emphasized the need to integrate all areas of the research. Dr. Furlow agreed and noted that basing decisions on historical weather patterns could lead to overinvestment. It is important to understand how much storm water can be controlled with some of these soft infrastructure approaches. If this can be quantified, the reliance on community storage and treatment systems could be reduced, and communities could avoid digging up streets and building large tunnels. Managers of combined sewer systems are interested in these alternatives; nobody wants to dig up a city or spend money on a tunnel that can be used only to hold water. Dr. Scheraga added that this raises the issue of prioritization and the role of the decision inventory. The types of information and the characteristics and attributes of different classes of decisions that currently are being made are being examined to help determine where the program can provide information and where it will have the greatest impact.

Regarding the riparian calculator, Dr. Furlow commented that one of the challenges is to weave all of the elements together and communicate the potential for each to the decisionmakers. In the publicly-owned treatment works study, as total maximum daily loads (TMDLs) are brought into effect and loads are allocated among different dischargers, nonpoint dischargers and point

sources may wonder who will bear the burden of reducing these pollutants. The riparian calculator may help quantify and allocate some of that load. Dr. Furlow added that some trading between point and nonpoint sources has occurred and might increase in the future. The calculator might help to achieve that. Dr. Coutant suggested adding reservoir systems research to the water quality focus area. The need for additional storage reservoirs has been identified as a possible response to climate change.

Dr. Russell mentioned episodic events and nonlinear changes in events, such as contamination of facilities. The natural cleaning processes of estuaries and river systems have been satisfactory in many cases; however, additional loadings that may come from change (i.e., land use change as well as other types) might reach a point where a system that was in equilibrium over a long period of time suddenly tilts out of balance. One of the goals is to understand where those tilt points might occur, both in the riparian strategy and in the estuary nonpoint source strategy. Dr. Russell asked about information needs that would be required to predict when immediate action is necessary. Dr. Furlow replied that the program has not developed a formal approach to the issue, but it has considered potential thresholds and recognizes its importance. The effects of temperature thresholds on the aquatic ecosystem is another topic of interest. Dr. Scheraga added that this topic is addressed in a new ecosystem RFA that was issued jointly with the U.S. Department of Energy (DOE). The greatest research gap right now is in the ecosystem area. Information from this research will link back to Dr. Furlow's work.

Dr. Wilkinson recommended that the program also address tilt points for infrastructure, such as levees and surface storage systems. He noted that the water issue is fundamental across the board and is seriously under-funded. Dr. Scheraga agreed and explained that resource allocation often is driven by the "loudest voices" within the Agency. When this program was reoriented, OAR was one of the loudest voices and received a large part of the funding. OW is more concerned with day-to-day regulatory enforcement than future climate change, and has not partnered with the program to a great extent. He added that this feedback is very helpful.

Health

Dr. Balbus commented that the posters and the presentations were very well put together and provided a concise overview. He explained that the health area presents some unique challenges because there are many tiers in the mechanistic chains and many data limitations that make it difficult to develop models for prediction. The program recognizes that there are different categories of work, all of which need to be pursued simultaneously, and it is accomplishing this. This effort involves laying foundations for establishing mechanistic relationships, which do not exist in the health arena, for many of the program's outcomes. Consequently, the program is conducting historical analyses (i.e., analyses of past climate variability and health), and it has been one of the only sponsors of that type of work. It also is developing these models while conducting global assessments, which was the mandate of the 1990 Act. The assessments had to be completed, with limited tools, and used to inform the research and continue these iterative loops. Dr. Balbus emphasized that the program has done exceedingly well, especially considering all of the challenges.

Partly because of these challenges, there has been a sequence of phases. The health area in Phase I, the U.S. National Assessment, identified research gaps and led to Phase II, which seeks to answer specific research questions. The difficulty is that the program's resources are insufficient to approach the health area adequately through specific research questions. This

approach does not reveal the big picture, particularly because many of the largest health effects are secondary and indirect, and they often are related to economic and psychosocial impacts of climate-related events. Therefore, the health area may be at a cusp, moving from a focus on answering specific research questions to the new decision-analysis focus. Dr. Balbus considered this to be an appropriate direction, given the limited resources and the difficulty of trying to model and predict numerous secondary effects. He recommended an information-gathering phase that includes input from stakeholders and public health practitioners. Dr. Balbus also noted that, with the establishment of the NPDs, the process for allocating resources was more centralized and deliberate.

Dr. Scheraga replied that he was encouraged by the Subcommittee's support for the move toward decision support, particularly because many of the biggest health impacts are caused by secondary consequences. He mentioned an episode of dengue fever along the border between Mexico and Texas. The number of cases in Mexico outnumbered cases in Texas by tens of thousands. The small number in Texas was a result of interventions, such as mosquito spraying programs. Although many analyses ended there, the Global Change Research Program has begun to examine the fate of these pesticides, especially in environments that have intense rainfall events. The consequences of such adaptation measures will have impacts on water quality and human health. Dr. Scheraga stressed the connection to the decision inventory, which will help present the larger picture and guide the research investments.

Dr. Balbus commented that secondary impacts often are more of an issue for developed countries than for developing countries. He noted that health impacts are likely to be mediated through economic forces and socioeconomic forces, which are very difficult to model. The Texas dengue episode demonstrates that society is willing to sacrifice the environment for the preservation of human health. This is where decision analysis becomes important; adaptation measures and the consequences of those measures can feed back into climate change (e.g., air conditioning can alleviate heat stress but, ultimately, might contribute to temperature increase). This type of information will be very relevant.

Dr. Russell added that secondary effects sometimes can be inconsequential; he stressed that negative results are as important as positive results and those research results must not be denigrated. In addition, because this is a relatively rich country, people adapt to climate change, and the consequences are not recognized as health effects. Adaptation measures also have a cost. Many health impacts of global change may be seen, not in the fact that more people die earlier, but in that a larger proportion of the nation's income is spent on preventing early deaths. This information is an important part of the program's research, and it underscores the importance of the work in terms of public policy.

Dr. Russell observed that society and the medical system adapt well to many, but not all, climate effects. It is important to determine which decisions will not occur through the natural course of events, but are important in the long term. He referred to these as "the dogs that are not barking now, but will bite some time in the future." For example, diseases that are not sufficiently prevalent to warrant private sector investment in new vaccines, in time could develop into matters of national concern. This is the class of issues that EPA can identify, but which EPA itself may not be able to address. These are "hard sells" administratively and bureaucratically, but they are the types of issues that a future-oriented program should consider.

Dr. Scheraga agreed with Dr. Russell's comments, particularly about the value of negative results. He mentioned that a recent study revealed that the risk of saltwater intrusion into surface water treatment plants was less than was anticipated and, therefore, communities would not have to over-invest in adaptation measures. Dr. Scheraga referred to an article, published 5 years ago, in which the program made the following points: (1) adaptation comes at a cost, (2) adaptation measures are not always effective, and (3) secondary affects of adaptation measures must be considered.

Dr. Scheraga mentioned the need for a process to determine "where to shine the light outside the lamppost." Many health effects are associated with ecological change. In addition, modern international transport can introduce pathogens that are not present yet in this hemisphere. If a pathogen or vector is introduced to a favorable climate here, a serious problem could result. The challenge is to choose smart research investments that are valuable in a socioeconomic sense, in a social welfare sense, and in anticipatory adaptation, and that is a challenge. Dr. Grambsch added that adaptation is a moving target, and infectious diseases are not conquered once and for all. Dr. Russell noted a Johns Hopkins University study that determined 36 hours would be required to stop airplanes from entering this country in the event of an outbreak of serious disease that would require isolating this country. Dr. Balbus mentioned the current potential for an outbreak of bird flu virus. This is example of an event that occurs thousands of miles away that could have an effect here.

Dr. Coutant cautioned about making judgments on the basis of negative results. For example, it should not be assumed that because saltwater intrusion in treatment plants is not a problem, that saltwater intrusion is not a problem. The major problem in South Carolina is saltwater intrusion into groundwater, which is the primary drinking water source. The study is not necessarily wrong, but it should not be concluded that saltwater intrusion problems do not exist. Dr. Furlow replied that the program is aware that groundwater is a prime source of drinking water, but the study did not address that. He added that the program conducted a study of groundwater sources in Florida that could be applied to other areas that rely on groundwater sources. He explained that from a national perspective, the surface water study appeared to be a good-news story. For those whose water supply is at risk, the situation is different. The program tries to balance a national perspective with the realities of specific locations.

Place-Based Assessments

Ms. Nierenberg commented that EPA deserves a great deal of credit for having maintained a regional strategy. During the U.S. National Assessment, it became apparent that the research needed to be conducted close to the stakeholders. The place-based focus area might provide an opportunity to reframe EPA's role in the regions, although that would be a major undertaking and a long-term commitment. It takes a long time to build relationships with stakeholders and to establish some institutional grounding. The place-based focus involves EPA's identity in the regions, which creates both opportunity and responsibility.

Ms. Nierenberg emphasized that the regional assessments produced a wealth of information for which the program should be recognized. This represents more than peer-reviewed journals, which generally are not read by those responsible for adaptation, and includes Web-based information, risk maps, emergency plans developed in partnership with states, and much more. Ms. Nierenberg also noted the opportunity for leveraging within the CCSP in such areas as education, training, and capacity building. She added that the regional assessments and the other

place-based work will contribute to the program's approach to decision support, particularly in terms of research that will have the greatest impact. The current learning in the regions could be a basis for which to reframe the program's interaction and the next set of announcements. The role of stakeholders and the role that this investment plays in discovery for the program are opening EPA up to new areas and new ways of thinking about its existing areas.

Dr. Slimak thanked Ms. Nierenberg and explained that the program has been discussing these issues and is at a decision point with regard to the regional assessments. Research and tools specific to tart cherry production can be important locally, but might not be relevant nationally. It can be misleading to focus on particular examples and assume that these are major concern areas. He appreciated Dr. Russell's comment about considering those areas that likely have no adaptive measures, what those sectors would be, and what those issues would be. This is the type of thinking in which the program is engaged.

Dr. Scheraga commented that the loss of stakeholder networks caused by the discontinuation of the U.S. National Assessment is a serious challenge for the program. The efforts to sustain networks that were established are difficult and expensive. The program has no expertise in the science of stakeholder engagement; it is learning by doing. Further, EPA and others involved in the U.S. National Assessment promised a long-term, ongoing process in return for stakeholders' investment of time, resources, and participation. Now, many stakeholders are unwilling to take another risk. Dr. Scheraga welcomed guidance from the Subcommittee about where to learn the science of stakeholder engagement. Dr. Russell commented that the program's budget for stakeholder-involvement research is very limited. He wondered if this should be pursued at all if the program cannot afford to pursue it adequately. Dr. Scheraga replied that the program is thinking about ways to measure the effectiveness of its activities, including those related to stakeholder processes. Dr. Wilkinson commented that he had coordinated a regional assessment in California that would have benefited greatly from follow-up work, and he recognized the value of EPA's place-based efforts. He suggested that the program continue to share its lessons with those in other parts of the country who find this important and useful. He mentioned the importance of maintaining networks of stakeholders and others for potential future opportunities.

Dr. Duke asked if the regional assessments could provide opportunities to integrate adaptation measures across focus areas. For example, Lyme disease is associated with changes in forest structure, so both the health and the ecosystems focus areas would be involved. Dr. Slimak responded that this was a good idea and fit with the program's direction. Dr. Scheraga added that this could be an opportunity for a solicitation. He mentioned an EPA quote from the 1995 assessment, "Water is the lynchpin." At that time, researchers had not begun to understand the implications of adaptation or the need for integration. Water was the one element that linked disparate sectors. Ms. Nierenberg added that the place-based ecosystems work is defined around watersheds, and the existing regional assessments are organized somewhat around water supply and quality. Dr. Reck commented that water is associated with all of the climate change capacity; the primary greenhouse gas still is water, and it has more impact than anything else. She added that the idea is very appropriate and she was excited to hear about it. Dr. Scheraga mentioned that, although the water quality work seems to focus on infrastructure issues, other focus areas address other water issues.

Dr. Reck asked if any group in EPA considers terrestrial ecosystems. Dr. Slimak replied that the air program has begun to explore the impacts of climate change on terrestrial systems, but EPA primarily is a regulatory agency. Most of its mandates involve water and air issues. Dr. Russell

explained that EPA focuses on elements that cross state borders, such as water, air, and endangered species. Dr. Coutant added that the Corvallis Laboratory has a strong emphasis on terrestrial ecology.

Decision Support
Dr. Christopher Pyke, EPA, ORD

Dr. Pyke explained that the decision support focus area is a work in progress that reflects a wide convergence of interests. The concept is very crosscutting and synergistic, and reaches across focus areas and divisions. Decision support provides a link between information, tools, and decisionmaking. The program's overriding goal is to provide effective and relevant decision support through: (1) collection of new data, (2) improved linkages between decision theory and decision support practice, and (3) strategic allocation of resources between decisions. Accordingly, the program combines research with practical considerations.

The program is assessment-oriented, and the purpose of assessment is to provide timely and useful information to decisionmakers. Assessments, however, cannot be presumed to lead to better environmental outcomes. The goal of decision support is to identify those activities that lead to better-informed management and policy decisions that improve societal/environmental outcomes. The program is not interested in the development of decision support *per se* unless it is coupled with some desired outcome (i.e., it is less interested in the tool than in what the tool does).

The field of decision support has grown significantly over the past 30 years, and the past 5 years have seen a dramatic increase in decision support related to climate change. Most of this research has been published by experts in computer science, engineering, operations research, or management; however, experts from many different areas also contribute to this field. Dr. Pyke explained that the definitions of decision support are very diverse, and there is no conclusion about the definition of decision support. In addition, the components and scope of effective decision support are diverse, undefined, and unbounded. There are numerous approaches to providing decision support that meet the goal of informed management and improved societal outcomes. Essentially, there is a great deal of decision work activity, it is being approached in numerous ways, and EPA and the CCSP are trying to enter the field.

There are two distinct elements of decision support: (1) understanding (i.e., concept and theory) and (2) application. Within the Global Change Research Program, decision support is driven by two imperatives. The first is the LTG of developing decision support for adaptation. The second imperative is a CCSP goal to develop decision support and encourage its transition from research and development to operational applications. This will be key to the whole concept of decision assessment and decision inventory.

<u>Understanding</u>

The program has been engaged in an internal dialog about the concept of decision support, which will be communicated through publications and presentations. The program also is sponsoring an NAS study under the auspices of the Committee on the Human Dimensions of Global Change. The objectives will be to: (1) elaborate a framework for climate-related decision support, (2) assess the strengths and limitations of strategies, activities, and tools, and (3) recommend strategies for organizing future decision support activities.

Applications

The Global Change Research Program defines decision support as "…any model, method, or information set supporting learning, increasing scientific understanding, and, ultimately, promoting adaptive environmental outcomes." The program's vision of decision support is much more extensive than a Web page or a printed manual, but it encompasses such products. Recently, the program has:

- ✧ Produced a manager's guide for coral reef ecosystems.
- ✧ Worked on the WEAP model for the Sacramento River.
- ✧ Supported development of the WALTER planning environment for assessing and reducing the wildfire risk.
- ✧ Modified the DRASTIC index for evaluating risks to drinking water.
- ✧ Evaluated tools for managing riparian areas in the Maryland Piedmont.

Dr. Pyke described the last example in more detail. He explained that climate and land use interact significantly in riparian areas. Local decisionmakers cannot change air temperature or storm frequency, but they can influence such factors as impervious surfaces and tree cover through protection or restoration. The program collaborated with the University of Maryland and local stakeholders to examine the implications of climate and land use on water temperature for aquatic invertebrates and fish. This provided a framework for adaptation that was relevant to local land managers and planners.

Although these activities were successful, the program was left with a sense that there was more to do, particularly considering the CCSP goal of progressing from research applications (i.e., proving the concept) to operational applications (i.e., a more widespread use of decision support). This led to the idea of a decision assessment. The goal of decision assessment is to identify those decisions to which targeted research and development of decision support are most likely to contribute to adaptive environmental outcomes. The focus is on decisions that are sensitive to climate or important to determining climate change impacts. Examples include:

- ✧ Design of flood control structures.
- ✧ Capacity of water treatment facilities.
- ✧ Management of water supply systems.
- ✧ Strategies for ecosystem restoration.
- ✧ Approaches to the detection and eradication of invasive species.

A decision assessment requires research to understand the characteristics of decisions, identify climate-related decisions that are relevant to adaptation, and prioritize decision support resources. Dr. Pyke explained that in developing prototype decision support systems, generally the system is designed around a given decision. If, however, the decision is not a given but is part of the system, it requires a certain set of data. The components of decision assessment include information, tools, and decision attributes.

Information includes environmental information, such as climate, geography, land use, and land cover. Analytical tools include statistics and models. Computer scientists and engineers have excelled in this area. For a given problem, they locate data and organize the tools. It is more difficult, however, to understand the characteristics of the decisions that are being served by the information and tools. It is important to be able to identify decisions that are climate related and relevant to adaptation. The goal, then, is to identify adaptation opportunities and have a framework for prioritizing decision support resources.

The first step in the decision assessment is to build a decision inventory, a foundation of data that includes: (1) decision characteristics (cost, frequency, reversibility), (2) context (rules, regulations, dependencies, technology), and (3) decision impacts, at least in a general way and ideally in a quantitative way. These impacts are economic, organizational, and environmental.

The program has started an inventory of adaptation decisions that will serve as a foundation for adaptation policy. It will be in the form of a book and a database, and it will provide a set of information to help prioritize adaptive opportunities. This product is analogous to EPA's *U.S. Greenhouse Gas Inventory*.

Dr. Pyke remarked that decision support will continue to be part of the Global Change Research Program, and it will encourage: (1) strategic allocation of resources, (2) improved linkages between theory and practice; and (3) more effective and relevant decision support practice.

Dr. Balbus asked about the term prevalence in the handout material. Dr. Pyke explained that, in this case, prevalence means how often decisions occur. For example, in reservoir management, the U.S. Dam Inventory can be used to determine the prevalence of reservoir management decisions that need to be made. A particular decision might be relatively low in cost, but it could be made 10,000 times per year by 1,000 different operators. The context about prevalence will help calibrate the importance of a decision, not simply its initial cost. Dr. Balbus asked about standardized terminology in this field. Dr. Pyke replied that he did not know of any standardized terminology. The program knows how to provide information but does not know how to categorize the data, which is one of its first tasks.

Ms. Nierenberg asked about the pilot study and whether there would be an advisory committee. Dr. Pyke explained that the overview he presented today will be the backbone of a pilot project. The first challenge in conducting a decision assessment is to bound the universe of decisions. The pilot will focus on one EPA region and decisions related to the four focus areas. The region will be used as a sampling platform for a stratified sample. Stakeholders who are associated with each of the four focus areas will be identified and consulted about the decisions they are making. The same process will be followed with the national programs and, in a few years, all 10 regions. The program will connect to the region stakeholders, who are the decisionmakers, learn what decisions they are making, and populate the decision inventory based on those decisions. This framework can apply to any large organization.

Advisory will be critical for this project. Because the effort is so broad, a disciplinary point person will be needed for each focus area. Each focus area will have contractors, a staff member, and one or more people who will provide guidance on how to proceed. As various issues are identified, the program will determine which are climate related. This is important because the program is most capable of making this determination, and because this will enable the program to direct its future activities.

Dr. Russell asked for examples of stakeholders. Dr. Pyke explained that the program will identify key decisionmakers. For example, stakeholders in the Chesapeake Bay program include the air quality board, the wetlands board, and various people engaged in flood control or restoration. The program will work with members of these groups to identify decisions they are making as well as the constraints and opportunities associated with those decisions. Many key decisionmakers who are engaged in ecosystem-related decisions are likely to be found in the Chesapeake Bay program. Dr. Russell commented that the stakeholders are self-selected because they already are involved with the region on a particular issue. Dr. Pyke agreed and explained that this is a point of compromise, but it is necessary to bound the universe.

Dr. Reck recommended that the program explore the Semantic Web, a tool with decision support capability, which is being applied to various agencies throughout the country. This might overlap with the program's efforts in this area.

Dr. Wilkinson commended the program for entering the field of decision support. EPA seems to be the only entity that looks across the entire country and across media (i.e., air, water) at human dimensions, human health, and ecosystems. He encouraged the program to participate in the emerging concept of integrated planning. This has existed in the energy field for a long time and has emerged in the water field in the past 15 years. This approach is being applied to water and energy planning at the state level and is becoming part of federal processes for policies involving greenhouse gas emissions, criteria pollutants, energy use, water use, and wastewater treatment. There is a need for good tools and methodologies, so this is an opportunity for EPA.
Dr. Coutant asked about advice and input from the social science community, and suggested an advisory committee. Dr. Pyke explained that the need for that type of input is recognized, but the ability to link to that information is weak. The program will take a step in this direction with the Human Dimensions Committee study. There are many lessons to be learned from management science and cognitive science, but engaging participants from these disciplines is difficult; historically, they have not involved with climate change. For example, part of the decision inventory involves identifying decisions in which the decisionmaker has some latitude to make choices. Management science researchers have thought about these issues and quantified them. This is referred to as "management discretion," and there are statistics for evaluating industries or parts of an organization to predict statistically which organizations and levels of managers actually have discretion to make choices. There are tables and statistical relationships, which can be applied to for-profit firms. Those tools are not available for institutions that address adaptation. The challenge is to bring those sets of tools, such as management discretion or other organizational analysis tools, into this realm and engage the right researchers. These researchers might be from business schools or operations research departments, and some are easier to find than others. The pilot is designed to engage in these exploratory activities.

Dr. Balbus commented that the regional office will be used to identify stakeholders, but that approach might not capture the public health decisionmakers. Will the program locate stakeholders outside of the current universe, and how will the comprehensiveness of the universe be evaluated? Dr. Pyke explained that the limited resources place a constraint on the universe. This is an infinitely scalable project; with more funding, the net could be cast much wider. It is uncertain how cost effective the program will be or how deep it should go. The beginning strategy will be to study the stakeholders that have been identified. Several hundred stakeholders are anticipated for each region. The program will study them as an organization and examine

their key decisions with respect to the four focus areas. A debriefing will follow the study. It is important to have some control over the terminology and how the universe is structured, which is part of the reason for the pilot. If this approach does not reach deep enough or broad enough, it can be restructured before proceeding to the next region. This model can be applied to any large organization.

Ms. Nierenberg asked Dr. Pyke if he was concerned that the different options for bounding the universe will affect the results. Dr. Pyke acknowledged that the procedure predetermines the outcome to some extent. The universe of decisions, however, is relative. The program is looking for the most valuable decisions of the set that is available. The universe will be limited by the sampling approach. This effort still is under development; there are many legitimate ways to proceed, and much depends on the particular goal. Rules are being developed, which can be modified as lessons are learned. Dr. Pyke added that the program will focus on large public or private organizations, but not small private businesses. He welcomed input from Subcommittee members and others as the pilot progresses this year.

Decision-Relevant Climate Impact Assessments Using WEAP21
Dr. David Purkey, Natural Heritage Institute

Dr. Julius introduced Dr. David Purkey, Director of the Water Resources Modeling and Analysis unit at the Natural Heritage Institute. Dr. Purkey has worked with the Global Change Research Program for several years. He is a researcher whose connections with numerous stakeholder groups has helped the program's work to be relevant and result in real outcomes.
Dr. Purkey explained that WEAP is a software package originally created by the Stockholm Environment Institute. It has been under development for approximately 15 years, and functions as a framework to assess climate change impacts. Dr. Purkey has been involved with its development for several years.

Dr. Purkey explained that a water resource simulation model is a tool to evaluate water supplies and demands. It begins with certain assumptions, such as the amount of water flowing at the top of a river, the amount flowing out, and water demands at given points. It also considers priorities, preferences, and regulatory and infrastructure constraints. Typically, these assumptions are based on history. Most models remove the entire water management system (i.e., infrastructure, demands, supplies, water rights, and regulations) from the dynamic hydrologic context and place it into a historic context. In the context of climate change, these historical inferences may not remain valid and, therefore, are not an effective way to determine future management adaptations.

WEAP, however, begins where most models currently operate. The WEAP model puts hydrology back into the water resource systems planning, and puts the water system in a hydrologic context. For example, the amount of water flowing down a particular river branch can remain unknown, because that is a function of climate, but components such as land formation (e.g., a rocky catchment) are known. Similarly, the total water demand can be unknown, but land use (e.g., cropping patterns) are known. Elements such as future temperature, precipitation, relative humidity, and wind speed for a future climate scenario can be added. The integrated WEAP framework takes this as the input boundary condition. The climate scenario is the dataset that forces the analysis. Instead of using past history, the model uses information, such as a steep rocky catchment that will have higher or lower precipitation and higher or lower temperatures, and generates the hydrologic response and the water supply. Similarly, the model

can begin with the crops in a certain area and let the demands be a function of the temperature and the precipitation that manifest under particular future climate scenarios. Certain crops, for example, demand more water during heat spells. WEAP has integrated a water resource systems planning tool into a dynamic hydrologic characterization and context, which can be forced with future climate scenarios.

Dr. Purkey explained that a hydrology model considers the physical processes that work in a watershed and answers questions, such as: How does rainfall on a catchment translate into flow in a river? What are the pathways that water follows as it moves through a catchment? How does movement along these pathways impact the magnitude, timing, duration, and frequency of river flows, which have ecosystem benefits, water quality impacts, and water supply implications? This leads to planning considerations, such as how water should be allocated in times of shortage, how operations can be constrained to protect the services provided by the river, how infrastructure should be operated to achieve maximum benefit, and how allocation, operations, and operation constraints will change if new management strategies are introduced into the system.

Dr. Purkey explained that the WEAP21 provides a framework to hydrology and water management questions that are forced by the climate that is being assumed through the future climate scenario. After this framework was developed, it was applied to the Sacramento River. A model was created that included all of the water management information that has to be balanced to meet various objectives. A calibration was done for the years 1961-1999, which examined flow along the mainstem and tributaries, reservoir storage and releases, agricultural demands, groundwater storage trends, water temperature, and other indicators. The results from the model matched the observed history fairly closely. With a certain level of confidence in the reliability of the model, the researchers then forced several different climate scenarios through the model. They looked at a range of precipitation and temperature levels and used the model to balance different supply and ecosystem considerations. The river temperature model indicated segments of the river that could support salmon in different climate scenarios.

This model enables water resource managers to recognize the various tradeoffs between ecosystems and water supply. EPA has funded several efforts to make this framework decision-relevant. The first activity was a model of the American River Watershed that will explore potential climate change impacts. The results of this study will affect decisions on such issues as hydropower operation, forest management policy, vegetation management policy, fire management, infrastructure, operations, land use planning, drought preparedness, and growth projections. The second decision-relevant activity was a collaboration with the California Department of Water Resources to determine whether the WEAP21 framework could contribute to the quantitative climate change assessment. A third activity involves a case study for the Sacramento Valley, which will involve issues such as water rights, irrigation technology, cropping patterns, and conversion of farmland to urban uses.

To summarize, Dr. Purkey explained that:

- ✧ The hydrology module is a powerful tool for considering changing catchment dynamics.

- ✧ Hydrology is essential for conducting rigorous analysis of climate change impacts.

- ✧ Hydrology can be used in sectoral economic analysis because it considers several resources in a catchment, rainfed and irrigated agriculture, forest and range management, and fish-appropriate flows.

- ✧ Increasing activity is taking place with the WEAP21 framework in California, with the real potential to influence decisionmaking processes.

Dr. Russell asked if the model could be used in other water systems. Dr. Purkey explained that WEAP is a generic tool that can be applied widely. Dr. Russell asked about the demand variable. Dr. Purkey explained that there are several elements of demand. One element is the type of crop in the agricultural sector. Another element is the consumptive demand (i.e., the evaporo/transporative demand), which is a climate-dependent element; for example, corn under hot conditions will have more demand than corn under cool conditions. WEAP allows both elements to be manipulated. Dr. Reck asked whether WEAP could be used in a flooding situation. Dr. Purkey replied that it is not a flood management tool because it does not handle routing. It is more of a water balance tool than a routing tool. Dr. Russell thanked Dr. Purkey for his presentation.

Extramural Awards
Dr. Ann Fisher, Pennsylvania State University

Dr. Slimak introduced Dr. Ann Fisher, leader of the Mid-Atlantic Regional Assessment (MARA). Dr. Slimak considered this assessment the best of the 19 regional assessments that were completed in the first U.S. National Assessment. Dr. Fisher and her team at Pennsylvania State University became the exemplar in terms of conducting regional assessments.

Dr. Fisher thanked Dr. Slimak and explained that she will discuss the role and contributions of extramural funding in the Global Change Research Program, using the two projects for which she was responsible as examples—MARA and the Consortium for Atlantic Regional Assessment (CARA). Dr. Fischer presented three major themes associated with extramural support: (1) nurturing next-generation scientists, (2) exploring key science questions for which answers have not been available, and (3) developing and demonstrating innovative assessment methods.

MARA, which was conducted between 1998 and 2004, involved 16 undergraduate students, 2 honors theses, and 2 senior theses; 44 graduate students, 8 Masters theses, 6 Ph.D. dissertations, and 5 post docs. CARA, which began in 2002 and is ongoing, involved 9 undergraduate students. One completed her senior thesis and now is working at the Federal Energy Regulatory Commission and working on a Masters Degree in the Johns Hopkins Environmental Policy Program. Approximately 30 graduate students are involved; 6 are working toward Masters theses; 3 are working on Ph.D. dissertations; and 3 post docs are included. Dr. Fisher commented that the students have been doing great work, and it has been gratifying to see them become excited about the science.

The regional assessments began by asking two key questions: (1) How might the region be affected by global-to-local changes in climate and land use/land cover? and (2) What information and tools do local and regional decisionmakers need to identify and plan for climate changes? To answer these questions, more emphasis was needed on regional and local scales, and integration across disciplines was required. It took approximately 2 years to find the right scientists and ensure they could communicate effectively—not every scientist is able to talk

across disciplines. In addition, the stakeholders (i.e., those who might be affected by climate change and those who are responsible for decisions) had to be considered.

The typical measure of success from an academic perspective is the number of publications completed. For the MARA, there were 67 publications in 16 major journals, 125 presentations, and 4 stakeholder workshops. An important MARA Advisory Committee also was established, which included more than 100 members. This committee provided input as well as review at different stages along the process. The Overview report and the Foundations report were sent to a much larger set of reviewers, and each report received more than 200 constructive comments. For the CARA, there have been 7 publications in 7 journals, 57 presentations, 3 major workshops with the CARA Advisory Council, and several small workshops with stakeholders.

Large, integrated, interdisciplinary research teams are required to answer key research questions. Pennsylvania State University is the lead organization for CARA, and 15 faculty members are involved. Carnegie Mellon University (CMU), the University of Rhode Island (URI), and the Virginia Institute of Marine Sciences (VIMS) also work closely with CARA. CMU and URI were chosen because of their expertise in decision science. VIMS was chosen for its strength in ecoscience and its ability to work with local stakeholders. The stakeholder participation on the CARA Advisory Council is quite broad; more than 200 people serve officially, which provides a large pool from which to draw for specific kinds of input or review questions. MARA and CARA both were designed for regional and local decisionmakers. The work, therefore, must be responsive to the kinds of problems that decisionmakers perceive, for which they have to make decisions, and which require the types of data and tools that they think they need, not just the ones the experts think they need. This is not always a close match.

Innovative assessment methods were pilot tested in the MARA under the U.S. National Assessment. Under CARA, the innovative assessment methods progressed from examining climate change only to climate change with the land use/land cover context as the multiple stressor of most concern. The information and decision tools will be available through an interactive CARA Web site.

Dr. Fisher believes that this effort is making a difference. Her team receives many requests for data and tools that already have been part of the outputs from MARA and CARA. Requests for MARA publications and media coverage continue. More importantly, citizen organizations, environmental groups, the League of Women Voters, regional commissions, state and local governments, researchers, and educators are requesting the information for use in making decisions. Planners in Cape Cod are working closely with researchers to understand how climate change can affect emergency response planning, particularly evacuation routes. Local officials had not been aware that some of these routes are likely to be under water as a result of climate change, so this research has made a difference in their planning.

Dr. Wilkinson asked if there was evidence to demonstrate the use of this work. Dr. Fisher explained that there was relatively little evidence that this work affected specific decisions, but she stressed that it takes a long time to build effective relationships with stakeholders. Cape Cod is a good example; outsiders are always outsiders, and it was an accomplishment to have the commission listen to the possibility that climate change might affect sea level rise. Similarly, in the Hampton Roads area, there is a great deal of work that explores the possibility of flooding on structures, such as entrance ramps on roadways. It is difficult to determine whether this work has affected decisions about repairing or replacing bridges. It might be easier to look back in 5

years and identify decisions that were affected by this work. Much of this still is not publicly available.

Dr. Balbus commented that the work is exemplary, particularly the amount of effort that was devoted to stakeholder involvement. He asked if Dr. Fisher had any wisdom to offer and, now that she has retired, what others are doing to maintain these relationships. Dr. Fisher emphasized the tremendous effort involved in building and maintaining a stakeholder network. She also emphasized the effort required to build and maintain an interdisciplinary infrastructure for conducting research. The strategy has been to meet often. It also is important to be aware of issues that stakeholders care about. Some stakeholders are easier to engage than others. For example, industry stakeholders have indicated interest in climate change issues, but they cannot spend company time on efforts that will not provide financial benefits in the near future.

Air Quality Assessments
Ken Colburn, NESCAUM

Dr. Scheraga introduced Dr. Kenneth Colburn as one of the most effective environmental policymakers at the state and local level. Until recently, Dr. Colburn served as executive director of NESCAUM. He will discuss the relevance of the Global Change Research Program to resource managers at the state level.

Dr. Colburn thanked Dr. Scheraga. He stated that the NESCAUM board is comprised of the air directors for the Northeast states. They are involved with many policy decisions and are using the information that is being generated in this program. Dr. Colburn commented that the program is heading in the right direction and noted an important cornerstone for effective state and local decisions: "If it is not specific to here, it is marginally useful." Dr. Colburn explained that when he was the air director in New Hampshire, legislators frequently asked him to "New Hampshirize" the data. It was not sufficient that global climate change was underway, they wanted to know what would happen there. Dr. Scheraga and Dr. Slimak were aware of that tendency, which is why the program now has a place-based strategy. Dr. Colburn stressed that it is important to understand what decisionmakers need. It is necessary to talk with them, which requires a great deal of effort over time. Eventually, stakeholders will contribute input that leads to better assessments and better tools, which create more questions and more input, and this creates an upward spiral. In this type of stakeholder engagement, Dr. Colburn commented that the program is doing very well.

Dr. Colburn stated that the program's areas of focused assessment also are very sound. Any static assessment, however, is not adequate for rapidly changing environmental and public health situations, such as those associated with climate change. Therefore, stakeholders want to have tools that will help them develop an understanding that is appropriate for their particular situation. This is the most important direction that the program has taken.

Dr. Colburn explained that climate change offers opportunities as well as risks. He stressed the value of information for developing proactive strategies to address opportunities, such as having the first mover advantage for designing new technologies or new areas in the marketplace. For example, several models predict a decline in maple, beech, and birch trees in the Northeast and an increase in oak and hickory. This information provides a competitive advantage for a business that is deciding whether to leave the paper making industry and enter the furniture making industry.

Dr. Colburn recognized that the United States needed an integrated modeling framework for air quality. He contacted Dr. Scheraga, and now the Global Change Research Program is funding development of a comprehensive model for air quality that will incorporate health effects, regional scale impacts, meteorology, and energy expenditures. It is hoped that, in the future, this model will provide key economic indicators to help governors make important policy decisions. This kind of integrated model has been missing, and the program is on the verge of producing it.

Dr. Colburn commented that the Global Change Research Program is proceeding in the right direction in the right way. The place-based and stakeholder approach meets decisionmakers where they are. This requires considerable long-term effort, but less effort will be required as the program's credibility and technical liaisons increase. Dr. Colburn explained that success is not static; the program needs to be aware of states' continuing needs. Air directors are particularly concerned about the impact of climate change on air quality, in part because the most important indicator of ozone nonattainment is temperature.

Dr. Colburn stressed the importance of developing more models, particularly for adaptation and health tracking. He also emphasized the importance of broader application. The program has done extraordinary work in several places. It is important to have these successful efforts implemented elsewhere, and this will require effective communication. He added that the program's current efforts merit additional funding.

Dr. Coutant asked if any of the work could be applied in Vermont, which is next door to New Hampshire. Dr. Colburn replied that he has been away from New Hampshire for a while now. He noted that, although there has been significant leadership in the Northeast on climate, most of it has been toward mitigation. Adaptation is subtle, and it can be a challenge politically because there is no traction yet for how to lead on adaptation, although hurricane Katrina may cause that to change. In terms of economic development, states should consider the security of their infrastructure. As a leadership point, a governor could argue that Vermont's infrastructure is reasonably sound. Currently, there is a New England governors/Eastern Canadian premiers effort, and there is a cap and trade program being developed for the Northeast states. One of the program's stakeholder processes soon will start in Vermont. Many activities are underway, but not nearly as many as are occurring in CARA.

National Program Director's Summary
Dr. Joel Scheraga, EPA, ORD

Dr. Scheraga thanked the Subcommittee members and emphasized the value of their work to the program. Dr. Scheraga explained that it was a daunting task to convey the essence of the program, which is complex and represents years of work. He added that the world is changing, the program needs to change with it, and he welcomed the Subcommittee's guidance. He hoped that the presentations conveyed the program's direction and accomplishments. He thanked the EPA staff, Drs. Colburn and Fisher, and the other participants for their commitment to this community and global science. He also thanked Dr. Slimak, who has been the CCSP principal representative for the Agency and has helped Dr. Scheraga assume many of his leadership roles and responsibilities.

Dr. Scheraga stated that he and the EPA staff tried to convey several key aspects of the program. First, the program is integrated and interdisciplinary. It has pushed the forefront in ORD in

bringing different disciplines together effectively. The program now has the flexibility to move resources and talent between and within focus areas and research issues, so that it stays responsive and relevant to clients.

The program faces a significant challenge in serving multiple clients. It must satisfy clients within the Agency in support of EPA's mission. The program also has responsibilities to the CCSP. This has been an advantage because the program has progressed from establishing a basic science foundation to learning to work with stakeholders to evaluate the science and understand its importance to those who use the information. This has made the program stronger, but has created responsibilities to people in the regions, states, and communities. The program has invested a great deal of time and effort building and maintaining those relationships. The program also has been active in the international community.

Dr. Scheraga commented that the program continually learns how to be more responsive. He explained that there is an iterative process between researchers, the assessments, and the decisionmakers, which creates a constant feedback loop that identifies priority research gaps and current and future decisionmaking needs. This helps guide the research program and demonstrates its flexibility. For example, last year the program moved away from work on emissions modeling, which the CCSP considered more appropriate for DOE, and applied those same tools to adaptation and other co-benefit issues.

Dr. Scheraga added that the program has been advancing the science in a systematic and meaningful way. For example, the program issued a joint RFA with DOE on ecosystem thresholds because this was recognized as a key research gap and a major concern to many decisionmakers. The program has accomplished many types of important outcomes as well as outputs. Dr. Scheraga emphasized the program's investment in fostering the next generation of scientists, which includes the development of new interdisciplinary programs within universities and other research institutions.

Dr. Scheraga stressed that this is a dynamic program, the demands are changing, and the staff continues to grow, learn, and improve its service to clients. He added that the funding outlook is not encouraging for federal programs. This program is evaluating how to invest in the highest value activities and how to leverage with other programs in the CCSP, in other parts of ORD and EPA, in industry, and elsewhere. He welcomed the Subcommittee's guidance in this area.

Dr. Wilkinson commented that the enthusiasm and commitment of the EPA staff was heartening and very much appreciated. Dr. Russell thanked the EPA participants.

Public Comments
Dr. Janet Gamble, EPA, ORD

Dr. Gamble announced that no members of the public had requested time to speak.

Subcommittee Work Session
Dr. Milton Russell, Chair, Global Change Subcommittee

Dr. Russell suggested that the Subcommittee members begin with a "brain dump" to present their impressions and concerns. These will structure the discussion for Day 3.

Dr. Duke commented that there is a large degree of opportunism in the program; it tends to emphasize issues that EPA has regulatory obligations to pursue or has existing strengths that coincide with those obligations (e.g., air and water). The regional assessments are based in places where EPA has had longstanding regional involvement. With the establishment of the NPDs, the program appears to be moving toward a top-down approach to planning, based less on history and opportunism, and this direction should be encouraged.

Dr. Balbus commented on the murkiness associated with the new emphasis on decision support, which seems to be an important aspect of the program's future. The shift in focus is appropriate, but he was not clear about how it will work. It seems that the program is not clear about it either. He added that it is difficult for the Subcommittee to support a direction that is so unclear. Ms. Nierenberg added that there seems to be confusion about how much to focus on decision theory and how much to focus on implementing a decision inventory to identify and prioritize issues. The program also needs a better connection to the CCSP, and it needs to redefine its role within the CCSP. The NSF is working on decision support theory; perhaps EPA could incorporate that work into its program. In addition, in some of the regional assessments, EPA seems to consider its role to be a climate service, which is NOAA's mission. NOAA has begun to work in this direction, and it has multiple resources that did not exist at the time of the U.S. National Assessment. There might be opportunities with other agencies or state partnerships that would allow EPA to revisit its identity in terms of stakeholders, decisions, and regional work.

Dr. Russell agreed and added that, although it would be interesting to do scholarly work on decision support and develop new tools, the question is why EPA should do that. He suggested that the program needs "rough and ready" ideas about how to choose which decisions to inform, not scholarly work that is being done elsewhere. Dr. Wilkinson cautioned that Dr. Russell's comments were rhetorical and not a statement. He noted the importance of developing methodologies and tools that are applied to and informed by the real world challenges that EPA faces across the mandates. It appears that, rather than a lofty academic exercise that will be published in unread journals, the decision support tools could be very helpful in calibrating investment decisions. Dr. Wilkinson explained that good scientific and economic information can be used by decisionmakers to determine real-world strategies, and there is a need for methodologies that are better informed. He considered this a positive direction.

Dr. Coutant commented that Dr. Scheraga was very successful in his interactions with stakeholders at the local level, and there has been continual, productive interchange ever since. The program could learn from the land grant universities' extension services, which bring academic research to farmers and fisheries. The best tool seems to be going out, talking up the program, and providing information. Dr. Reck noted that she works at a school of agriculture in the Department of Land, Air, and Water resources. She estimated that approximately one-half of the people in her department are representatives who work with farmers. She stressed that interacting with stakeholders is very effective if meaningful, cutting-edge information is presented. She also reiterated that the Semantic Web could be very useful for the program and suggested that Dr. Fisher's work could contribute to it.

Dr. Russell replied that this points to the issue of right work (i.e., investment and disinvestment). Dr. Reck explained that she did not think that the program should discontinue this work, but it should be aware of this tool and its applicability for the program before investing further. Dr. Balbus added that the Brookings Institution also is developing a Web of Knowledge project—assembling communicating databases and integrating multiple types of data (e.g., land

use, housing costs, and Toxic Release Inventory data). It is all part of the same movement, and this type of effort needs to be integrated into the program. Ms. Nierenberg commented that without careful management and oversight, the decision support effort could be very costly.

Dr. Coutant suggested that computer games could be developed from the models. For example, games could be created that demonstrate the consequences of increased temperature, rainfall changes, or sea level rises. These can be useful for analysts and state emergency managers as well as children.

Dr. Wilkinson commented on the importance of developing tools. These have practical application for policy work, particularly in the area of water, and better tools are needed. He envisioned simple tools coupled to information that the program generates or can access. These could support real-world decisions, such as sizing infrastructure or calculating tradeoffs. The program needs to have room to invent, make mistakes, and learn from stakeholders what works best. For example, resilience can be built into systems (i.e., better "sponges" as watersheds), so that the system can buffer the effects of high precipitation and release water during droughts. These are simple concepts, but they are extremely important for ecosystems and water quality and quantity. These options often are less costly than classic infrastructure options. No other agency seems to be conducting this mix of activities across all of the media, so EPA has an important opportunity. This work can support decisonmaking at the federal, state, and local levels in determining resource allocation and investment strategies to address potential climate change problems. Dr. Wilkinson emphasized that there are tangible economic benefits to making better decisions, and that message needs to be conveyed.

Dr. Wilkinson also mentioned the importance of integrating activities. For example, there are many air and water issues in the health and ecosystem areas. The work is very complementary, and it needs to be viewed as such; however, he acknowledged that it is difficult to allocate resources and conduct research in an integrated way. Ms. Nierenberg added that there might be opportunities to bring the integration concept to the regional strategy.

Dr. Russell commented that "many things that are worth doing are not worth doing well" and that "precision is the enemy of getting things done." The necessity of conducting activities well can hinder problem solving in the larger context. He added that, in the context of decision support; it is important to understand what is important. The decision support knowledge is so far from the existing state of practice that moving toward best available technology might be more valuable than improving and perfecting the technology. This seems to be a policy-oriented, practical program that is supposed to help solve problems. That provides a different framework for thinking about investments and resources than would be appropriate for a traditional research program. He added that he perceives this as a kind of tension.

Dr. Russell asked about investment in the regional programs. Is the program building the capacity to act nationally on a local level, or is it building decision support for tart cherry growers in Michigan? It seems worthwhile to build support for tart cherry growers as a means of understanding how decisions are made on a local level if those lessons are communicated and used elsewhere. If it is possible to achieve collective learning through the regional efforts, then the program should be directed to do so. Dr. Russell emphasized that this was an observation for discussion, not a conclusion.

Dr. Russell noted that resources are limited and likely will become more so. The program, therefore, is interested in choosing investments wisely. To determine the right work, it is necessary to think about the purpose of the program, which is to assist the nation and to make wise decisions that will improve the quality of the environment and keep people alive and healthy. He added that many conclusions can be derived from this premise. Dr. Balbus replied that stakeholder processes are not worth doing without sufficient investment. Striving for perfection might delay some activities, but it is important to conduct stakeholder processes well.

Dr. Duke stated that the materials did not indicate active collaboration with related programs at other agencies. CCSP is a cross-agency program, but it might not be collaborative. Either better evidence is needed, or collaboration is not occurring. Dr. Russell added that there probably is ongoing collaboration and leveraging, but unless this is made evident, the PART review and other evaluations will be less positive. That evidence, therefore, should be made available. Dr. Wilkinson added that it is important not to imply a criticism of the program. It should be stated in a positive way that there is tremendous value in the research and that efforts should be undertaken to encourage collaboration. Dr. Russell added that there is history that makes it difficult to change courses instantly, and there are many other imperatives that cannot be changed.

Dr. Reck noted that Dr. Fisher's work was not funded completely by EPA. That effort was funded at more than $2 million for 3 years, and approximately 20 people were involved. She explained that the work has progressed such that Dr. Fisher believes that it could be repeated elsewhere for $500,000. Dr. Reck suggested that if the federal government could fund half of that amount, local counties might be able to fund the rest. She commented that Dr. Fisher's team has produced an extraordinary tool for presenting climate change events and consequences.

Dr. Russell commented that he was concerned about the idea that if EPA's regional efforts are discontinued, the whole process will fall apart. If that is the case, the question becomes who cares. The answer is not necessarily that no one cares; it is that there is no institutional structure. If stakeholders must be held together by extensive care and feeding, are they stakeholders? He stressed that this was a question for discussion, not a conclusion. Dr. Wilkinson replied that this points to the issue of metrics for evaluating accomplishments. He explained that he was involved with regional assessments in California that did not receive follow-on funding. Those stakeholders still are very interested, and significant state-level activity now is building on the work and the relationships that were established. This is evidence that people care and are moving forward with investments and decisions. The regional approaches to climate change are extremely important, and many regions do not have this type of support and stakeholder effort. Dr. Wilkinson suggested that maintaining a focus in the regions could provide an opportunity to build on lessons learned and identify activities with nationwide applicability. Ms. Nierenberg agreed that there could be opportunities, possibly with federal or federal/state partnerships. NOAA is investing in regions but for different reasons, and no other agency has the same breadth or the mandate as that of EPA. NOAA's program invests high at first, then plateaus, and then funds less as it requires new partnerships to support the effort. There might be opportunities to encourage EPA to look at the regional question in more innovative ways. Dr. Reck noted that state organizations, such as the California Air Resources Board, are funding global change research. The combination of local, regional, and federal funding might be the most effective strategy, and perhaps EPA could encourage that collaboration with matching funds.

Dr. Coutant suggested that the regional concept be maintained, but the regions could be redefined by biome rather than geographic location. This relates to the blending of focus areas that Dr. Wilkinson mentioned. In the International Biological Program, the biomes that defined the regions were the foundations of its regional approach. There was an Eastern deciduous forest biome and others, which were broken down into ecoregions with common ecological problems. Dr. Russell added that this would imply an approach based on problems rather than geography (e.g., problems pertinent to an urban region).

Dr. Russell described the Subcommittee's work session as "a kind of blue sky operation with vagrant thoughts," and it should not be considered indicative of the Subcommittee's conclusions. He then adjourned Day 2 of the meeting.

WEDNESDAY, SEPTEMBER 28
Dr. Milton Russell, Chair, Global Change Subcommittee

Dr. Russell welcomed the Subcommittee members to the third day of the meeting and reviewed the day's agenda. Dr. Duke will discuss the first chapter (i.e., the "wisdom chapter"), then each focus area leader will present an overview of his or her chapter. Dr. Scheraga will answer questions about the PART review and related issues. The Subcommittee will discuss crosscutting issues and major findings to be highlighted. The Subcommittee will prepare a preliminary report, which Dr. Russell will present to the EPA staff and to which Dr. Scheraga will respond. Finally, Drs. Russell and Scheraga will present concluding remarks.

Discussion of the First Chapter

Dr. Duke thanked Dr. Russell and explained that the first chapter will begin with introductory material, such as the purpose of the review, charge questions, and the program review process. Today's discussion will identify major recommendations and conclusions to highlight in the wisdom chapter. Dr. Russell will write the Subcommittee's premises, the program's premises, and an explanation of the questions "Is this the right work?" and "Is the work being done well?" He and Dr. Duke agreed this material should be presented up front. Dr. Russell added that it is critical for the Subcommittee to be in agreement about these issues.

Dr. Russell described the research premise: multiple climate changes may be ahead. These changes can be gradual, gradual with thresholds, or sudden and catastrophic, and may involve such factors as increased ultraviolet radiation, population, and land use. These changes, to the extent that they occur, will create multiple stresses. The strategic goal of the program is "to provide the highest priority science results to improve expected values of outcomes as valued by residents" (i.e., outcomes valued by the people, not necessarily by the directors of the program). This requires improving the knowledge base on which decisions are made. The guiding principle of the program and the selection of research topics should be to illuminate choices. This will involve providing support for decisions that will be the most valuable or highest priority contribution from a national program such as that of EPA.

Dr. Reck commented that choices will have a regional component, and that one choice may be better for one region than another. Dr. Russell agreed to include this in the text. Dr. Balbus suggested that they broaden the language. The program involves more than illuminating choices, which implies a focus on adaptation strategies; the program also provides tools to assess potential impacts, which will help determine appropriate adaptation strategies. He also

commented on the word "residents" and suggested additional target audiences, such as policymakers and utility managers. Dr. Russell explained that he tried to choose an all-encompassing word; he has been criticized in the past for using the word "citizen," which does not include many people who live in this country. He was more concerned about including the international and global responsibility; however, for the PART and other such reviews, the program should consider its client to be the people of the United States.

Dr. Russell referred back to the guiding principle. He recommended that the program start by asking: (1) What are the prospective needs for action in the context of global change? (2) What are the consequences that would require action to be taken? (3) What is the initiating change (e.g., sea level rise)? and (4) What are the scientific tasks that are required to understand these relationships? The reason for this approach is that a pragmatic, problem-solving, decision-support program must begin where it can do the most good and then determine the direction for the science, rather than start with the useful and interesting science and then look for a way it can be used. Scientific research usually is thought of in the opposite way—supply-driven rather than demand-driven—but this is not that kind of program. Dr. Russell added that these were comments for discussion, not conclusions from the Subcommittee.

Dr. Balbus commented that the Subcommittee's review is both retrospective and prospective. Currently, the program is in the second phase of a transition from a situation in which the possibility of global change was not accepted universally. The initial phase, therefore, was more supply-driven. Now, the premise of global change is well accepted in the scientific community, and the program must progress accordingly. He emphasized that the report should not imply that the program should have started with a supply-driven approach. He added that Dr. Russell's description of the top-down approach will help explain the concept of decision support.

Dr. Reck commented that changes in air quality were more important to consider than sea level rise. Dr. Russell explained that he mentioned sea level rise only as an example. Dr. Reck noted that certain issues that generally are not considered important could become major concerns. EPA could be in a difficult situation in a very short time, for example, as a result of temperature change.

Dr. Russell introduced the next discussion topic—criteria for selecting future work. He explained that the program's primary function is to inform decisions that will make a difference and to develop the appropriate tools.

Starting with the presumption that there will be incremental climate changes, Dr. Russell explained that if people who are subject to those changes are able to adapt on their own, then EPA will have little influence. For example, farmers can choose to grow different crops in response to a change in climate conditions. People will forecast and behave differently if the initiating change and the capacity to respond to the change are held in the same hand. There are other circumstances, however, in which EPA research can improve the quality of decisions, such as:

- ✧ Cumulative changes that reach a tilt point or threshold. If these types of changes are foretold, adjustments can be made that would not be possible otherwise.

- ✧ Decisions that are not in the hands of individuals. Many decisions require collective action (e.g., infrastructure investment). These types of decisions require political action that

normally would not occur without foresight and understanding, such as decisions with long lead times, high investment costs, and subtle changes leading to differences in investment.

- ✧ Protection of unmanaged systems. For example, it is in no one individual's interest to ensure that birds continue to migrate. These types of decisions and the way to make these decisions must be a federal determination.

- ✧ Provision of information services that are social goods, such as credible, early warning of prospective changes. It is in no one individual's interest or ability to understand prospective changes that might occur; this is a type of a collective responsibility that must be met by a collective body.

- ✧ Development of adaptive mechanisms that require investment or lead time (e.g., developing a response to potential infectious diseases). It is not in the drug companies' interest to develop vaccines for which there is no current market; yet, it is in all of our interest to have those vaccines developed—that is a collective social good.

- ✧ Shortening the process of discerning and reacting to global change. This includes building tools to understand and react to change.

- ✧ Improving the ability to identify and communicate prospective changes. This includes reducing impacts on those who can adapt on their own.

- ✧ Sudden change (i.e., low-probability/high-consequence events). These are the types of events that one insures against. Adjustments for sudden-change events might require long lead times or high investment.

Dr. Russell noted that these are areas in which EPA's action today can have a high payoff in the future. These are important issues and, if the federal government does not address them, they will not be addressed. Dr. Duke mentioned events that are likely to be repeated, such as hurricanes. Dr. Russell agreed that repeatable events caused by climate change, such as increased storm intensity, would be in that category.

Dr. Russell explained that identifying and evaluating investment opportunities along these criteria will result in a suite of potential areas from which EPA can determine the highest payoff. He also mentioned the importance of decision tools to understand the implications of second-order consequences. Individuals and first responders generally see only first-order consequences of an event, but second-order consequences can be significant for decisionmakers. Understanding these implications requires building models and other activities, which are collective efforts appropriate for EPA.

Dr. Wilkinson recommended using consistent terminology. The NRC refers to rapid climate change as "abrupt climate change." The term "variability" includes such events as hurricanes, floods, fire, and drought cycles. There might not be terminology for the intermediate, large-scale impacts, such as coincidences or series of events (e.g., the two recent hurricanes). He also emphasized characterization of secondary effects. Much of the discussion, particularly in the health area, concerns the immediate effects of an event, such as a heat wave or a levee break. People die in these events, but secondary and tertiary effects often are significant and complex, and thoughtful research is required to understand the connections and implications.

Dr. Russell described an example of secondary effects. In an underprivileged section of Los Angeles, waste oil was spread on the streets to reduce dust. This was considered a good solution at the time, but the oil was found to contain dioxin. EPA relocated the residents to save them from a "one-in-a-million risk" of harm from the dioxin. A follow-up study showed that incidences of spousal abuse, abandoned children, divorce, alcoholism, and drug abuse, were alarmingly high for the people who had been dislocated. A holistic view would have recognized that the dioxin had a far less chance of negative health impacts. These kinds of effects will not be anticipated if only first-order consequences are considered.

Dr. Reck mentioned secondary consequences from the recent hurricanes (e.g., effects on the localities that accepted evacuees and disruptions to institutions, such as Tulane University). She commented that EPA, with its decisionmaking tools and its perspective of secondary and tertiary consequences, might be an appropriate agency to consider these issues. Currently, no logic or science is being applied.

Dr. Balbus noted the difference between secondary effects of primary global change and secondary effects of adaptation to the primary, secondary, and tertiary effects of global change. The present discussion is about secondary effects of adaptation measures. In a decision support framework, those distinctions are important; there is a difference between mold caused by receding floodwater in New Orleans and social disorders in Houston caused by an influx of evacuees. Dr. Balbus noted that this is only a $12 million program, and suggested that EPA might consider these issues, but it should seek additional federal support to do so. He also emphasized the importance of training the next generation of scientists, which currently is a goal of the program.

Dr. Coutant commented that the top-down emphasis was an important recommendation. A program can easily become science-driven, particularly in the ecosystem focus area, because there is so much to research. Dr. Russell explained that the report recommends a needs-driven approach to prioritizing opportunities that already exist. The program does not have the resources to drive the science.

Dr. Gamble reminded the Subcommittee members that their review should include both a retrospective and prospective analysis. Dr. Russell asked each of the Subcommittee members to share their views of the program's past and future. He began by emphasizing that this is an able program, run by quality people who have done excellent work.

Dr. Wilkinson stated that his reaction to the program also was very positive. He recommended more integration of the focus areas to increase the synergistic value of the research. The report also should ensure that the existing synergy is recognized. He thought that the decision support area was good, but it should be defined carefully so the program will not try to do too much.

Ms. Nierenberg commended the program for being self-reflective, for its strong mission orientation, and for its strong personality within the Agency. She also commended its effective use of the STAR Program. She would like to expand the discussion of the "right work" to include the right bridging function and the right interaction with stakeholders. There might be ways to help EPA build on its strengths and accomplishments. Now that the U.S. National Assessment era is past, it might be time to reconsider the program's LTGs. She added that the program has done an excellent job on science issues.

Dr. Coutant agreed that the program is exemplary and has accomplished a great deal of excellent work in the ecosystems area. The difficulty is that there is so much that could be done and very limited resources. The program should consider whether the work it has selected is truly representative and generates products that are applicable nationwide. Some projects have had excellent site-specific benefits, but might not provide generic benefits as well. He explained that this was not a criticism, but a suggestion for how to evaluate past work. The Subcommittee could suggest directions prospectively but, retrospectively, the program has done a very good job. Dr. Coutant asked about the number of examples to include in the report and how to sound both positive and constructive.

Ms. Nierenberg commented that PART reviews can have the effect of giving credit for being agency-oriented and not giving credit for being interagency-oriented. Many of the suggestions under consideration are about EPA's role in a broad public policy framework, which seems like the right direction. She added that it would be interesting to see EPA receive some credit for its interagency accomplishments.

Ms. Nierenberg explained that, initially, the federal global change effort was successful because of its interagency budget and approach. Global change now is far beyond science agencies; it is a mainstream public policy issue. Many of the direct effects of global change and the secondary and tertiary consequences are addressed in mainstream policies, such as emergency management planning and agricultural planning. These big-picture issues, particularly the value of the program's role in the larger framework, are important to include in the report.

Dr. Russell mentioned the difficulty of conceptualizing and managing a program that is both amorphous and complex. He commented that the OMB should evaluate how well EPA is accomplishing the large public policy mission, but it seems to be measuring identifiable milestones. Ms. Nierenberg added that EPA's mission requires integration across the government. The Agency could be a significant resource for improving the capacity for science to inform decisionmaking in specific contexts.

Dr. Coutant replied that Ms. Nierenberg highlighted an important issue. At the time of the National Assessment, the emphasis was on research needs. Now the focus is very different; the implementation agencies are responsible for emergency management and other activities. There has been an evolution within the last 5 years from a research focus to a decision criteria focus, which is the correct emphasis for the program. The program review should explain that the program met its earlier mission, but that the mission is evolving.

Dr. Reck commented that her background includes an appreciation for chemistry and rate of transfer in addition to global change modeling. She explained that for many years, neither of these constituencies would acknowledge the other's significance. Those who look at the dynamics of the atmosphere did not want to admit that there was any chemistry involved, and those who were involved in global climate change did not want to think about anyone using their results to plan for the future. Each was an isolated world. She commended the program for making each of these groups recognize the others' importance. She considered this a vital step forward. She also commended the program for putting climate change and air quality in a reference frame so that the effects can be examined together.

Dr. Balbus commented that regional assessments might not be the most cost-effective approach to leveraging resources. Other efforts, such as the partnership with NESCAUM, provided a wealth of tools and examples that can be shared widely. His organization faces a similar issue—to accomplish change on the ground, one must work regionally, not nationally, but working regionally requires additional resources that are not always available. He recommended finding leaders in the regions (i.e., in water districts or air quality management districts), providing tools and examples, and setting the direction with the hope that the effort will be replicated in other locations. Dr. Coutant added that the missing step is to translate the site-specific, organization-specific efforts into a generic product that can be advertised as available.

Discussion of Focus Areas

Health

Dr. Balbus remarked that the challenge in the health focus area is a lack of data and foundational work to establish linkages, quantify those linkages, and foster development of predictive models for health outcomes. The program has done a remarkable job in progressing in multiple areas simultaneously, especially in the health area. It completed an overall assessment, used that assessment to identify key research gaps, and set out to fill some of those research gaps. Early warning system tools were developed for heat stress and hantavirus, which are saving lives right now. The program's health-related products include: (1) literature reviews and descriptions of the state-of-the-science, (2) retrospective epidemiologic studies to develop quantitative linkages, (3) development of conceptual frameworks for models and model development, (4) assessment work, and (5) workshops and training sessions. He commended the program for its balance of activities and its flexibility in moving from one to the other.

He noted that the program sequenced its work to accommodate activities that require development of up-front tools, such as vector-borne disease research and air quality models. That was very appropriate and followed earlier guidance.

He added that the quality of the work was demonstrated by the high quality of the journals in which it is published. The program has integrated intramural and extramural research very effectively. In terms of outcomes, he emphasized the two tools that currently are saving lives. These are important from proof-of-concept and PART standpoints. The program has been a world leader in the global change and human health community from the beginning, with efforts such as creating a center at Johns Hopkins University, editing books, and working with the World Health Organization.

Dr. Balbus indicated that the air quality modeling and the health impacts research should continue. He commented that creating an interface with health decisionmakers is not an easy undertaking, and suggested an advisory group comprised of representatives from local and state public health agencies, major insurers, and representatives of major urban hospitals (i.e., people who make decisions that affect the national economy, emergency response, and public health efforts in the United States). This group could conduct decision inventory work and determine which issues are climate sensitive and what types of tools are needed. Dr. Russell noted that the function of the advisory group would be to elicit wisdom, rather than evaluation, from the participants. Dr. Wilkinson added that such a group would be a form of stakeholder engagement.

Dr. Balbus recommended emphasizing that secondary effects of climate change can be as severe or more so than the primary event. These include secondary effects of climate events as well as adaptation measures. He noted that when public resources are redirected for adaptation measures, social programs often are the first to be cut. Dr. Balbus added that incorporating these complex interactions into models and primary research is a difficult undertaking.

Dr. Balbus noted that the lack of sufficient data and models is daunting and is beyond EPA's purview. To the extent that the program tries to fill research gaps, he agreed that it should be a top-down, needs-driven process. Ms. Nierenberg suggested that EPA could identify requirements that other agencies might address more ably. This might be a crosscutting theme. EPA has a certain high-level, integrative view and is getting better at identifying decisions. The Agency might be in a position to articulate data, resource, or information needs for other agencies to fill. Dr. Balbus replied that the "unstated statement" is that EPA is filling a vacuum in this area. Perhaps it should be stated, not as a recommendation or a conclusion, but as an observation. Dr. Wilkinson suggested characterizing this in a positive way; EPA is trying to address a critical research need, but it lacks sufficient resources to do so. Dr. Russell added that it is a positive social need; EPA is performing its small part of the mission, but the mission on the whole is not being performed.

Dr. Reck asked about malaria research. Dr. Balbus explained that other institutions conduct intensive work on malaria, and he would not recommend that EPA invest resources in that area. Ms. Neirenberg asked about international efforts. Dr. Balbus recommended against this direction because of the program's limited resources.

Water

Dr. Wilkinson commented that the water focus area is an important area with excellent ongoing work. Much of the work, however, was captured in other focus areas, such as the ecosystem area. He noted that the program is targeting long-term, capital-intensive, and potentially irreversible actions, which seems like a good direction. The program is focusing on water quality issues, which are important, but it should go beyond that. He added that the ecosystem services approach seems very good and should be strengthened. This is included in the ecosystems focus area, but it is very specific to water. Land use design strategies are covered in both focus areas, but opportunities exist through land use planning and design. Dr. Wilkinson recommended strengthening linkages between the four focus areas and with the regional and decision support areas to leverage the research more effectively.

The focus on water quality is highly appropriate for EPA; however, because water quality and quantity are linked inextricably, it is important to consider efforts that provide multiple benefits. The program seems to understate the end-use efficiency opportunities, such as groundwater recharge and water reuse. EPA's other work in these areas could contribute to the climate change effort. Dr. Wilkinson emphasized the opportunity to enhance decision support through an integrated approach rather than the current "stove-piped" approach. He also noted that the current budget is inadequate for the potential that exists in the water area.

Dr. Wilkinson noted the importance of developing tools and methodologies to help decisionmakers quantify the costs and benefits, based on the science. He also recommended strengthening the relationship with the Office of Water and the regions.

In regard to stakeholder opportunities, Dr. Wilkinson also recommended an advisory group to provide practical advice (e.g., contacts for specific efforts). This would provide a valuable cross-fertilization function as well as help maximize the research efforts. He added that the excellent work in EPA and elsewhere should be tied together more effectively. Dr. Coutant noted that the crosscutting nature of the water quality area is both an advantage and a disadvantage—either it is dispersed throughout the other areas or it is focused too narrowly.

Dr. Russell asked about the retrospective and prospective view. Does the current work support important future decisions or are there other higher priorities? Dr. Wilkinson replied that, retrospectively, the program has done very well. The work, however, spans the other focus areas; he will have to examine those areas to determine the full range of accomplishments. He added that the program could leverage other opportunities.

Dr. Coutant mentioned a study that determined saltwater intrusion in the coastal zone was not a problem. Not only was the conclusion inaccurate, but also the approach was too narrow to recognize the broader picture. Coastal plain areas of South Carolina, where groundwater is the main source of drinking water, face an acute problem with saltwater intrusion. The program, however, analyzed drinking water treatment plants and concluded there was no problem. Dr. Wilkinson agreed that many localities face saltwater intrusion, and added that there were other dimensions to the problem. He was considering the program's strategy and direction rather than specific findings, which he intends to investigate.

Dr. Balbus asked what the water quality work is supposed to support. Initially, he thought it would support the human health area through a focus on drinking water quality. Much of the work, however, seems to be dominated by issues such as land use and estuarine riparian water supplies, and not tied to human health. Dr. Wilkinson replied that the primary drivers are the CWA and the SWDA. EPA is the only agency that addresses these issues across the country and across the board. Its mandate under the CWA is to ensure water quality for the environment (i.e., safe water for fishing, swimming, and other uses). Human health issues are covered partly under the CWA and SDWA. The program's accomplishments benefit both human health and the environment, but they have been presented in bits and pieces. Most of the work addresses human health (e.g., wastewater treatment and drinking water), but the nexus to ecosystem and watershed health—to meet those legal mandates—is not as clear as it needs to be. Benefits from both areas of work can be synergistic. Ms. Nierenberg asked if the nexus would be through the Endangered Species Act. Dr. Wilkinson replied that several laws drive these issues, and that would be one. Ms. Nierenberg suggested a panel that would consider implementation issues and information needs.

Dr. Wilkinson described an EPA-funded calculator that analyzes watersheds and the effects of climate change under very specific scenarios. Information from this tool can be applied to a wide range of issues (e.g., endangered species, water quality for human health, ecosystem and habitat issues, and others). This is an example of a research investment with broad applicability that supports sound decisions based on good science.

Dr. Wilkinson was concerned about how to write the report with so many overlapping issues; EPA's accomplishments do not fit neatly within the given matrix, and he wants to ensure the report does justice to EPA's past work and future plans. Dr. Russell noticed a discrepancy between the way different types of impacts were responded to and treated. In some cases, adaptation was the mechanism between climate change and impact, and the costs of incremental

adaptation were ignored. In other cases, the focus was on climate effects of direct concern to residents.

Dr. Reck commented that global change conditions could affect lake levels in the Great Lakes, which could create significant health, environmental, social, and economic problems. Many jurisdictions would be involved, including both the U.S. and Canadian governments, and it is not clear whether EPA would have responsibility. Dr. Reck remarked that this potentiality is not being discussed.

Dr. Wilkinson agreed that there are many issues that need to be addressed, and although EPA has responsibility for water quality, the program resources are limited. He asked how to articulate the need for more resources without sounding critical of the program. Dr. Duke replied that comments about resource constraints have been included in all of the BOSC program reviews to date, and it is a legitimate area for comment.

Air Quality

Dr. Reck stated that the program has excelled in bringing global change and air quality modeling activities together and into an assessment framework. She commented that it is difficult to determine the best climate model and to address the sensitivities attached to an outcome in a given scenario. Scenarios change; for example, precipitation may increase or decrease. Consequently, it is difficult to use these models for planning. Dr. Reck explained that the program has performed the work very well, but there is a dilemma about how to describe the uncertainties in the results from these different scenarios.

Dr. Reck explained that the linkage from global and regional levels to more local levels is very important. The program is observing emissions correctly by considering both natural and anthropomorphic emissions, which must be analyzed separately to determine suitable control strategies. She summarized that the program's approach and accomplishments are very good, but she is concerned about how to put the sensitivities into a reference frame that can be used for integrated assessment and decisionmaking.

Dr. Reck noted that the program also uses energy system modeling, which likely exists in other sections of EPA. It was not clear if the program has made that connection. Dr. Russell commented that the air models probably are the same ones being used in the Office of Air and elsewhere in EPA. Dr. Reck replied that there might be some controversy attached to the model being used; the program should be clear about this issue. Dr. Russell replied that the Subcommittee should assure itself that this work has been done properly.

Dr. Reck commented that other organizations have made substantial advancements in the area of decision support. The program should investigate and consider applying the latest research.

Ecosystems

Dr. Coutant explained that the ecosystems focus area has a well-defined role in the program, based on EPA's mission and the program's evolution. Its focus includes the CWA and the President's Ocean Policy. Dr. Coutant commented that the program is conducting the right work, but there is a great deal of needed work in this area. The challenge is to determine which

efforts to pursue, given the available resources. He added that the program is well conceptualized and the quality of the work is very high. Dr. Coutant noted the following points:

- ✧ The program activities are on target and consistent with resource availability and likelihood of success.

- ✧ The program is evolving nicely from a research focus, based on the 2000 U.S. National Assessment guidance, to a decision-support focus.

- ✧ The program has emphasized stakeholder engagement. Initially, the program had to search for stakeholders. Currently, there are more stakeholders than the program can serve. This has been well balanced, despite the diversity of stakeholders to assist.

- ✧ There are questions about whether the place-based regional assessments are being used effectively. The program is conducting other site-specific work, and there is an integration question there.

Dr. Coutant commented that activities should be selected to represent both topical and locational needs. He also recommended addressing episodic issues in addition to the gradual-trend issues. He suggested the formation of an advisory group that would include representatives from science and academia (e.g., the Ecological Society, the American Fisheries Society, and the North American Benthological Society), managers from implementation agencies, and representatives from the social sciences. The idea is to include implementers with a social as well as a technical perspective.

Dr. Coutant stated that the program is performing well. The research is appropriate and has been published in high-quality publications. The STAR Program has been used effectively, funding projects specific to the ecosystem focus area mission. Stakeholder feedback has helped to identify research gaps. The program's initial research emphasis has progressed toward a more stakeholder, decision-support direction. Dr. Coutant commented that environmental outcomes are difficult to determine; it is easier to track publications than to know whether the research has benefited the environment. Examples of the program's leadership role include Susan Julius' activities with the American Fisheries Society and Dr. Scheraga's extensive travel and interaction with stakeholders. Overall, this is a large, high-priority focus area, which is combining practical application with research and accomplishing as much as possible with limited resources.

<u>Place-Based Regional Assessments</u>

Ms. Nierenberg recommended that the Subcommittee endorse regional place-based work. It is an effective way to merge scientific insights, pressing issues, and decisions associated with environmental policy. She noted that place defines context and institutional capacities, and it will be part of the decision support and stakeholder strategy, regardless of the Subcommittee's recommendations.

Ms. Nierenberg explained that EPA "performed its community service" under the 1990 Global Change Research Act, which mandated regional assessments. There is a strong sense that regions will return to the CCSP, so there is a different context today. The U.S. National Assessment infrastructure that defined the Phase I and Phase II announcements no longer exists,

but there still is a need for place-based work. This makes it challenging to develop recommendations for EPA.

The program is conducting a great deal of excellent place-based work in addition to the regional assessments. It recognizes that the mission is to provide the right kinds of decision support, the right methods for engaging stakeholders, and the right bridging functions.

To determine an appropriate regional strategy based on the current circumstances, several questions should be considered. EPA traditionally has had a strong role in certain regions. What should be the nature of EPA's role before heading into Phase III, and will there be a Phase III? This question involves issues of stakeholder engagement, decision support, and resource allocation. Four years ago, the program was advised to move toward an assessment orientation. How might this evolution be reflected in a new regional strategy? How can the program continue to contribute to its highly integrative successes, its successes at integrating across the focus areas, its successes at bringing these issues to decision relevance and, now, its interest in identifying actual decisions where it can make a difference? Should the program continue to work in the same locations—are these the right places given the overall program strategy today?

Ms. Nierenberg explained that NOAA and other agencies have developed climate information services. EPA's regional assessments were involved somewhat in providing climate information services, so this could provide leveraging opportunities. The Subcommittee should encourage the program to think integratively about its next step.

Ms. Nierenberg suggested a regional scoping meeting in which EPA could (1) revisit its role in the regions; (2) examine recent developments that have redefined its role in those regions; (3) determine whether there will be new targeted announcements for regions, with specific requirements for cooperative agreements; and (4) determine whether there is a phased approach that could be used by the program.

Ms. Nierenberg commented that the presentations did not mention an LTG for the regional focus area. It was suggested that the implementation of the 1990 Global Change Research Act and the U.S. National Assessment was the LTG. The program should consider a new LTG in light of the program's evolution. Dr. Balbus asked if there was no current LTG because it had been achieved. Ms. Nierenberg explained that the goal was achieved in a certain timeframe; however, the goals have been redefined. The program is being forced toward an interagency framework, but the interagency reality has changed. The LTG was based on an interagency commitment to a unified plan. Without the U.S. National Assessment, that plan no longer exists, but the legislation still does. There is an active issue right now in Congress and between the Administration and Government Accountability Office (GAO) about the extent to which EPA is responding to the 1990 Global Change Research Act, which requires an assessment every 4 years; so there is a conflict.

Dr. Scheraga added a few clarifying points. The 2001 Research Strategy included, as an LTG for this regional activity, a commitment to meet the requirements of the Global Change Research Act. The Act requires an assessment of eight different, clearly specified sectors, every 4 years through 2010. One assessment has been completed, but Senators McCain and Kerry and the Congress are questioning why a second assessment has not been done. The CCSP, under Dr. Mahoney's leadership, responded by stating that "the requirements of the Act will be satisfied by December 2007," not in the same form as the first U.S. National Assessment (i.e., a

single assessment report), but through 21 synthesis and assessment reports, to which the program is contributing. The scope of these reports has been expanded to cover all of the sectors that are required in the Global Change Research Act.

Dr. Scheraga explained that LTGs that contribute to a product are no longer sufficient; the products must contribute to human health and environmental outcomes. This is not yet reflected in the research strategy. Dr. Russell asked what the regional assessments had to do with meeting the requirements of the Global Change Research Act. Dr. Scheraga replied that the Office of Science and Technology Policy (OSTP) and the Administration defined the activity that would fulfill the original requirement. Now that the requirements have been rescoped as synthesis and assessment products, the issue is the mechanism by which information will be produced for those products. Dr. Scheraga explained that products were his choice, not a Congressional imperative. Dr. Scheraga indicated that the 21 synthesis and assessment reports were described on page 17 of the Strategic Plan overview document.

Ms. Nierenberg commented that there has been discussion about why EPA was organized the way it was, in a certain context, and with certain expectations. A more productive consideration is where their own progress leaves them today in terms of reframing a regional strategy.

Discussion of the PART
Dr. Joel Scheraga, EPA, ORD

Dr. Russell asked Dr. Scheraga to discuss the PART review and any other considerations that could affect the outcome of the program review. Dr. Scheraga explained that, prior to the recent reorganization, all ORD budget decisions were made by the Executive Council, which is comprised of Laboratory and Center Directors, the AA, the DAA, and additional ORD representatives. The Executive Council had difficulty organizing and implementing meaningful budgets for crosscutting programs; consequently, NPDs were established to improve the process.

Dr. Scheraga elaborated on some of the bureaucratic challenges. In 1998, before NPDs were established, there was a dramatic shift in the program. The transition to an assessment orientation required investment in assessment activities, in particular, the National Assessment. A significant amount of money (approximately $1-1.5 million) was transferred from other laboratories and centers to the center responsible for managing the regional assessments. The loss of funding caused some resentment. A deeper issue, which still lingers, is that "assessment" has many different connotations. Dr. Scheraga explained that when he uses the word assessment, he does not use the term "stakeholder-oriented," he refers only to "policy-oriented assessment." Many people do not consider assessment activities to be real science. In addition, many people do not understand the implications of the science for their own work. Dr. Scheraga explained that these individuals are well intentioned and want to respond to the program offices, but they have a very set notion of what type of science is required and do not view assessments as consistent with that. Every year since 1998, when the annual budget was submitted to the Agency from ORD, recommendations have been made to cut the program. There was one exception when the AA intervened at the ORD level and made it clear that the Administration wanted to keep the program.

When budget requests were submitted, typically OSTP and/or OMB would notify the Office of the Chief Financial Officer (OCFO) that the program could not be cut. Three years ago, ORD wanted to cut the budget significantly, but OSTP did not allow it. This year, climate change was

a priority in Dr. Marburger's annual memorandum that indicates the Administration's priorities. This had a big influence on OCFO, and the directive was issued that the global program could not be cut. Jim Mahoney was instrumental in this decision. He has worked very hard to have CCSP develop an integrated budget, which has been delivered for the second year to OMB. This will be very helpful, despite the appropriations process on Capitol Hill, in which each agency has its own appropriations committee. Having such a memorandum go to OMB when the President's budget is prepared will be very important.

The PART exercise, which was implemented by the Bush Administration, is a business school model for evaluating progress. There is much to be said for it, particularly if outcomes can be demonstrated with well-defined metrics (e.g., tons of SO_2 reduced). Research programs in EPA have not done well in the past few years. The Ecosystem Research Program flunked the PART review 2 years ago. The NPD for that program faces a big challenge in explaining the benefits of basic ecosystem research to an OMB examiner. PART scores are used by OMB in developing the President's budget submission. Because of its low PART score, that program's budget was cut by approximately $40 million. It flunked the PART review again this year with a lower score, even after 2 years' experience with PART and everything that is known about the criteria. This is a very serious issue. There is an arbitration process if OMB and the Agency cannot agree on the score. An arbitrator is appointed, in this case from the State Department. It is unclear why the failure occurred; although it could be justifiable, there is consternation about the process. The GAO conducted a review of the PART process, which apparently was critical. Capitol Hill hearings followed, and OMB has been trying to improve the process.

Dr. Scheraga commented that research and investment criteria (i.e., relevance, quality, performance, and scientific leadership) were legitimate issues for review. He explained that the biggest challenge for any research program is to demonstrate measurable outcomes. The PART exercise requires a description of how outcomes are measured and progress is quantified. This appears to be key to a passing score. From a business standpoint, OMB asks programs to explain what the government is buying. This is important for the program to articulate. It is difficult, however, as a producer of intermediate products, to convey what the government is receiving. This difficulty is compounded by the fact that the research programs are reviewed separately from the program offices in the PART review process. The Toxics Research Program and the program office underwent the PART review at the same time. Rather than being evaluated as a single unit, each was examined separately and, although the program office fared well, the research program did not. Dr. Scheraga is concerned about the PART review because the Global Research Program is not a regulatory program. The entire CCSP is concerned about this and, at the recommendation of NASA, it commissioned an NRC study, which did an excellent job of articulating metrics for research programs. The Global Change Research Program, because it is an assessment-oriented program that provides information to decisionmakers, might be in a better position than most programs within ORD to articulate how it is influencing decisions; however, it has no control over what adaptation decisions are made or how many lives are saved. This is the challenge facing the program in terms of the PART review.

Dr. Scheraga explained that the program faces political sensitivities as well. For example, certain terminology is not permitted in many documents. This indicates the kind of political environment in which the BOSC program review will be examined.

Dr. Scheraga explained that NPDs work as matrix managers. When he was a National Program Manager, he also was a matrix manager. The difference was that Dr. Paul Gilman wanted to

ensure that the new NPDs would have budget authority. Acting AA, Tim Oppelt, decided to implement this, and it became his challenge to define budget authority. Currently, although NPDs do not sit on the Executive Council with the Laboratory and Center Directors, they contribute to the budget process. At the beginning of the President's budget process, the Executive Council provides broad guidelines, by program area, about investments and disinvestments. In the global program, for example, Dr. Scheraga will receive the Executive Council's weighted recommendations as guidance by LTG and focus area. Intense discussion will occur between the NPDs and the Laboratory and Center Directors about the recommendations. The NPDs will provide recommendations back to the Executive Council. NPDs have some budget authority, but the Executive Council has the final word. Within ORD there are checks and balances, and NPDs are not on an equal footing with Laboratory and Center Directors. Dr. Scheraga mentioned the close relationship with the OAR . The Global Change Research Program and OAR are collaborating on the November CCSP workshop.

Dr. Russell thanked Dr. Scheraga and remarked that he and the Subcommittee appreciate the difficulty of his task and have the highest respect for the staff and leadership of EPA.

Dr. Reck asked if the Subcommittee could review the funding guidance to identify any sensitivities that could affect the program review inadvertently. Dr. Scheraga replied that the guidance is part of the 2007 budget process, which is confidential. Dr. Duke added that it would not be appropriate for the Subcommittee to review the guidance, but he stressed that the report will be written carefully. He added that these concerns warranted discussion within the BOSC Executive Committee. Dr. Russell reiterated that he and Dr. Duke will be sensitive to the concerns that Dr. Scheraga described, but emphasized that the Subcommittee is an independent advisory group, which will present its own conclusions.

Dr. Coutant asked if the results of the Ecosystem Research Program's PART review were available for review. Dr. Scheraga replied that he would find out, but he thought it was part of the development of the President's budget request and, therefore, confidential. Dr. Gamble noted that the PART Web Site contains summary information about PART reviews across agencies. Dr. Gamble will send the URL to the PART Web Site to the Subcommittee members. Dr. Phil Russo added that results of previous PART reviews are available on the OMB Web Site. Dr. Gamble will provide that URL as well.

Dr. Wilkinson mentioned that two projects, the Basins work in California and the watershed calculator, were presented at a major conference of water managers from across the West. The work was so well received that one of the water managers provided copies of the disk to everyone there at his own expense. Dr. Wilkinson commented that Dr. Scheraga might not be aware of this, and asked what mechanisms were available to gather such data for PART reviews.

Dr. Scheraga replied that he relies on the Assistant Laboratory Directors and Assistant Center Directors for such information. He had asked them to document accomplishments and outcomes, which he will provide to the Subcommittee. He also explained that the emphasis on outcomes is new for the program; it now is in the process of establishing a database to monitor and document outcomes on a regular basis. PART also allows testimonials from program partners to be included as evidence, although presentations are not allowed. The NRC report on metrics will influence the program's submission to PART next year.

Dr. Wilkinson asked about the cost of inaction. For example, research had predicted severe consequences for New Orleans in the event of a surge; the failure to use that information was devastating. It is difficult to demonstrate the value of information for events that do not occur—information is valuable, even without a disaster to confirm it. This is a difficult area to quantify. Dr. Russell noted that this is referred to as the "expected value," which is a combination of the probability and the value if an event were to occur. He added that, many years ago, OMB was attuned very closely to this type of reasoning and interpretation. Dr. Scheraga replied that, according to other NPDs, there is a wide variance in OMB examiners. Some understand the concept and some do not. He explained that OMB examiners ask what the program has spent money on, not what it could do, and ask what has been gained from the investment. This program tries to provide a dollar metric for damages avoided for some activities, such as combined sewer overflow work. He and his staff prepare for the PART reviews themselves, and it might be wise to draw on expertise from other sections of EPA. Dr. Scheraga added that one of the motivations for the BOSC program reviews is to help inform the PART preparation.

Ms. Nierenberg suggested that the NRC report and the information about metrics will be useful to all of the research agencies, which also are struggling to articulate their outcomes. At NOAA, OMB uses skill scores, but as environmental conditions change, scientists will know less, and skill scores will drop, even though performance does not.

Discussion of Crosscutting Issues

Place-Based Regional Assessments

Ms. Nierenberg stated that it was not necessary to delve further into the U.S. National Assessment issue. She had raised it earlier because the context was relevant to the retrospective evaluation of the work. That context also relates to the interagency emphasis, which the Subcommittee seems to be encouraging. The role of assessments is important, but this chapter should offer constructive suggestions about moving forward.

Dr. Wilkinson asked about the terms "place-based" and "regional." Dr. Scheraga explained that "place-based" is preferred. There are sensitivities associated with vocabulary, and there is an increasing recognition that the work involves conducting assessments in particular places rather than regions.

Dr. Wilkinson commented that tremendous progress has been made in climate change research and public understanding of its potential impacts. New technologies allow sophisticated work to be conducted at local levels, and EPA's work in the regions must change accordingly. There is a significant need for place-based work because of the unique nature of places and the way decisions are made. The program should consider ways to leverage its experience in the three regional assessments and move forward. There could be opportunities to build on this and meet real needs throughout the country. It may call for a reinvention of what was called regional support. Dr. Wilkinson suggested a two-part recommendation: (1) a validation of the past approach and an effort to learn from that work, and (2) an invitation to think anew about what would be valuable moving forward, given that the circumstances have changed.

Dr. Russell suggested that, although much has been accomplished over the past several years, there may be little reason to continue in the same direction. This does not mean that the work was not valuable; it means that the work is now "ready for harvest." Dr. Wilkinson stressed that

there is need for place-based work, but what to do and how to do it must be reconsidered. Tying these efforts to the four topic areas and their decision support functions is extremely important.

Dr. Russell added that in the first few years, the function of the regional effort was to build stakeholders who could become interested in this issue, but Dr. Wilkinson is describing a different set of stakeholders (i.e., decisionmakers and information users who make decisions on a place basis). An example of this type of stakeholder would be water resource managers in the Tennessee Valley who must optimize energy production and transportation in a changed world. Ms. Nierenberg added that this demonstrates the strength of the program. In the past 4 years, it has moved toward a highly integrative framework, which is leading to new classes of decisionmakers and decisions.

Dr. Reck commented that, with multiple groups interested in an outcome and perhaps buying from the same resources, she could foresee competition and serious political issues. Dr. Russell suggested that the country needs this kind of political conflict to produce a robust policy. Dr. Reck mentioned Love Canal. In that small space, there were 31 different jurisdictions. Serious issues of authority and responsibility were exacerbated by the fact that it was located on the U.S. and Canadian border and Indian tribes were involved. There was no real resolution, which is a concern because the global change research effort is undermined if resolution is not considered possible.

Dr. Balbus commented that he did not understand the problem. Was it that for a given place and a given decision, multiple agencies with jurisdiction would compete for EPA's resources, or was it that the inability to determine authority would cause a stalemate? Dr. Reck replied that the problem is about who makes decisions. Love Canal had many significant, far-reaching implications, even 20 years later, that no one would have anticipated. The 31 jurisdictions each had their version of the way things should have been settled, and the company that caused the original damage walked away with no responsibility.

Dr. Coutant commented that all of the program's work occurs in the context of a particular place, but regions, as historically defined, are no longer the appropriate place. Dr. Wilkinson replied that he thought place-based work should remain part of the research program, but suggested a reconsideration of how to approach it and how to apply it nationwide. It should include stakeholder interaction, communication methods, and an effort to determine priority issues in each location to connect the scientific research to real world problems. For example, in California, scientists were sure that electric utilities needed certain information about sea level rise because of the coastal and hydroelectric power facilities. The utilities, however, had sold the coastal power plants and completed modeling on the hydroelectric facilities. They were concerned with landslides and forest fires. Dr. Coutant suggested that they consider shifting stakeholders. Although the Pacific Gas and Electric Corporation does not own Diablo Canyon, somebody owns it and has to worry about it.

Dr. Russell summarized that there is a national need for numerous efforts. The question becomes what can EPA do through this program that would be most effective in assisting such a process. Dr. Wilkinson thought something could be done within a reasonable budget framework, perhaps an inventory of existing stakeholder programs.

Dr. Coutant asked if it would be wise to invest in a major effort that cannot be complete (i.e., because it does not include all of the country), uses politically troublesome terms and

considerations, and might not be as productive as subsuming those same functions into the focus areas, which are trying to incorporate both the generic, broad-scale aspects and the place-based ones.

Dr. Scheraga agreed that the program's activities occur in specific places, but if the work is subsumed into the four focus areas, the integrative nature across focus areas will be diminished. This includes the four focus areas and others that might be important. Dr. Russell asked if that integration had taken place and if there was any evidence for it; the integration he has seen appeared to be limited to process. Dr. Scheraga replied that it has occurred to varying degrees in different regions. For example, in the first Great Lakes regional assessment there was some excellent work that integrated water and ecosystem changes. This varied across regions because of the institutions' analytic capacity at the time. He added that this aspect can be enhanced through the solicitation process by requiring a certain skill mix and type of integration. Other examples exist, which could help the Subcommittee.

Ms. Nierenberg commented that there had been discussion about the extent to which those regions integrated effectively across the focus areas and fed back to the program. That came through in some places and not in others. The question is, what is the best use of place-based work in the program to help it move forward in this integration. She added that there is a new reality now and, in places where other regional assessments exist, EPA might suggest a set of decisions to address, whether or not it remained in the regions.

Ms. Nierenberg suggested that the Subcommittee draft recommendations that allow room for innovation within the guideline that place, stakeholders, and integration are important considerations. Other important components include collective action, information services, discerning and reacting to global change, and identifying and communicating prospective change. She suggested these as guiding principles for how to revisit the regional component.

Dr. Russell stated that, initially, there were many reasons to involve universities, create a consortium, and build grassroots attention, but that effort might not be necessary any longer. Now, it is time to ask how the function of decision support in different focus areas can be accomplished more effectively, in a place-based basis, as part of the overall program.

Dr. Balbus asked about the tension between a needs-driven regional effort, which might be less integrative, and an integrative regional assessment, which might focus less on developing decision-support tools. A place-based effort that develops decision-support tools for a specific utility in a particular location, which could be replicated elsewhere, would seem to be more effective than going into a geographic area, enlisting stakeholders, integrating across sectors, and determining activities for that place.

Dr. Scheraga replied that he did not perceive a strong divide. Those who are interested in a cross-topic effort and those who are interested in particular topics, such as ecosystems or human health, all have learned that it is best to start with decisions. Once a collection of priority decisions has been identified, the NPD chooses a set of decisions for each focus area and identifies decisions that require assessors, analysts, and researchers to integrate across several focus areas. The starting point is decisions. Certain classes of decisions might be relevant to specific information users, such as water resource managers, and others may require integration.

Dr. Russell thanked Dr. Scheraga and added that his clarification has been very helpful.

Decision Support

Dr. Russell explained that decision support is a new direction, which is asserted to be a driving force in the direction of the program and a topic area in and of itself, rather than something inherent in everything.

Dr. Coutant mentioned the use of the top-down approach in the context of decision support. As an example, he explained that decisions will have to be made concerning Atlanta's water supply. These are not broad decisions about water resources across the Southeast, although those are relevant. More specifically, the need is to determine how to manage river flows in the region to ensure sufficient water for Atlanta and the Apalachicola ecosystem. This issue would benefit from a top-down approach that would integrate focus areas, such as water and ecosystems.

Dr. Russell commented that there are two ways of thinking about decision support: (1) directing the allocation of resources within the program, and (2) applying resources toward making better decisions. Dr. Duke added that another consideration is the difference between decision support within each focus area (i.e., developing applicable decision-support tools) and decision support as a stand-alone element. Dr. Russell replied that he thought the issue had been presented as a stand-alone entity.

Dr. Wilkinson noted that Dr. Coutant's example illustrated the need to identify important research questions through a place-based, policy-relevant approach that also can demonstrate the return on investment. A decision-support program should build in metrics and approaches that help identify the decisions that need to be made. Atlanta's water issue is tied to competing interests between ecosystems, water supply, wastewater management, and other considerations. There are many possible strategies (e.g., increase supply, enhance efficiency), all of which have implications that need to be considered. In the context of climate change, there could be increased variability (e.g., it may be wetter or drier). With the right information, decisionmakers can formulate appropriate and cost-effective strategies. A decision support program, therefore, should be connected to specific places and build on the focus areas, but also provide a mechanism for making policy decisions outside of the "stove-piped" focus areas.

Dr. Russell asked if Dr. Wilkinson was suggesting integrating the decision support into the focus areas, rather than having a separate decision-support component. Dr. Wilkinson explained that there is a need to develop some usable tools and metrics. He did not know whether a particular focus area should develop tools that, eventually, could be used elsewhere, or a separate decision support effort should investigate how to obtain usable tools. Either way, those tools will need to be tested and used in the health, air, or water arena. He suggested a center of excellence to develop decision support research, which would be test-driven and used in the focus areas.

Dr. Balbus reiterated Dr. Reck's earlier point that the program should be involved with ongoing developments at the Brookings Institution and elsewhere related to Internet-based, integrated datasets. Decisions related to such issues as water management and land use are being supported through these efforts. Dr. Wilkinson agreed but added that he was recommending strategies to quantify multiple benefits from the program's research investments. This requires new thinking, not necessarily new models, but the tools did not seem to exist.

Dr. Russell summarized that the question is how to improve decisions and support decisionmaking, wherever the issues happen to be. To do that, EPA's role might be to adapt, change, or simplify existing decision tools. This could involve a research center of excellence program, but it is not developing new algorithms for decisionmaking under uncertainty.

Dr. Reck added that any type of decisionmaking measure is limited by the data used and the compatibility of the different datasets' characteristics. It is difficult to take information that is very limited in one area and very broad in another and combine them. There is a great deal of information available, but what information should be used, and what criteria should be applied to ensure that the right data are used? EPA might be qualified to evaluate the composition or character of datasets because it has been using them for a long time and knows more about monitoring than many other agencies. This could be part of a decisionmaking activity, which also could help other agencies.

Ms. Nierenberg suggested a pilot phase to test some of these issues. Currently, NOAA is involved with a Decisionmaking Under Uncertainty award that is cataloging climate service users. This has some overlap with the issue under discussion. A pilot also could help the program understand how far to go in the area of decision support (i.e., should it study decisionmaking or catalog decisions?). There might be a way to use the Decision Inventory to determine what it could do for the program. Dr. Coutant agreed with Ms. Nierenberg and noted that EPA has good decision-support flow charts and other tools for ecological risk assessment and causal analysis. The trend within the Agency is to develop standard approaches. A first step would be to try to adapt existing tools.

Major Findings
Global Change Research Subcommittee

Dr. Russell remarked that the prospect of summarizing the past 3 days seemed very daunting. He asked the Subcommittee members to suggest major findings to include in the first chapter of the draft report.

Dr. Wilkinson recommended including a very positive overarching message about the program and the people involved (i.e., their commitment, integrity, performance, and approach), and the Subcommittee agreed. Dr. Balbus added that the Subcommittee came to consensus quickly on the major issues (e.g., the "right work" has been done, the work has been done well, and the transition to a more decision support-oriented approach was appropriate).

Dr. Wilkinson added that the context for the program should be mentioned. The program is addressing important questions with very serious health, economic, environmental, and social implications. There is a true need for understanding the dimensions of global change, which is becoming more urgent with time. Ms. Nierenberg added that the program has built the capacity to use scientific information. It also has the opportunity to support major public policies and contribute to the rebuilding in the Gulf Region (e.g., by articulating vulnerability).

Dr. Russell emphasized that the prospective evaluation should not imply negative conclusions about past efforts. Dr. Balbus added that this includes recognition of capacity building that has occurred in the past.

Dr. Russell reiterated the point that it is difficult to measure outcome on low-probability/high-consequence events in a year with no major catastrophes. An outcome can be the capacity to avoid damage. Dr. Duke commended the programs' self-reflective quality, which demonstrates its leadership and adaptive capacity. The willingness to recognize and implement appropriate changes will help maintain the viability of the program. Dr. Reck emphasized that the program should be commended for integrating many diverse areas, such as chemistry, dynamics, and energy systems.

Dr. Coutant recommended endorsement of stakeholder involvement for two reasons: (1) this helps focus issues on the decisions to be made, and (2) the stakeholders, not EPA, are the implementers. There must be a connection between EPA research and the ultimate outcome. The stakeholders make the decisions and produce the outcomes, so stakeholder involvement is very appropriate and necessary.

Ms. Nierenberg added that the program deserves credit for having been deliberate about participation. There are layers of stakeholder involvement—involvement within the focus areas, regional involvement, and commitment to the community (e.g., Dr. Scheraga briefing groups of mayors). The program has been sophisticated in its approach to stakeholders; it has considered equity issues, participation, and technical and nontechnical stakeholders; it has not simply opened up in an unmanaged system. This approach is helping them progress in the area of decision support. The program should investigate questions about who uses the information, what decisions have been affected, whether the information mattered, and whether and why it was not used.

Dr. Russell differentiated between stakeholders as any group coming together for discussion and stakeholders who make relevant decisions under specific circumstances and who have a stake in the research. Dr. Wilkinson recommended explaining the term stakeholder in the report to ensure clear communication. Dr. Balbus commented that the definition of stakeholder underlies some of his confusion about the regional assessments. His original interpretation of stakeholders was a group meeting where people could voice their concerns. To Dr. Scheraga, however, stakeholder engagement might mean determining key decisionmakers in particular areas.

Dr. Russell suggested that in the first phase of the place-based assessments, the first description of stakeholders was implied, but for the future place-based work, the second definition of stakeholders is more appropriate.

Dr. Wilkinson commented that he has seen both kinds of stakeholder groups. For example, NOAA workshops associated with the last El Niño event in California included those individuals who were responsible for relocating people, ordering snow removal equipment, and shutting down major infrastructures. Most of the stakeholders involved with various regional assessments also were major decisionmakers. The Subcommittee should encourage a diligent effort to engage those types of stakeholders. Dr. Russell added that, for future PART reviews, outcomes can be demonstrated with those decisionmakers; other outcomes are much more difficult to demonstrate.

Dr. Balbus commented that EPA's Office of Information is involved with integrated databases, and could possibly assist in developing or adapting decision-support tools that involve climate data. Dr. Reck added that many people will recognize the Semantic Web.

Dr. Russell mentioned that the draft report must be completed by the end of the calendar year.

Final Remarks to the EPA Participants
Dr. Milton Russell, Chair, Global Change Subcommittee

Dr. Russell thanked the EPA participants and asked them to convey his appreciation to those who were not present, including managers and staff at all levels. He also thanked Drs. Scheraga and Gamble. He explained that his summary of the Subcommittee's general conclusions was a first draft and would not necessarily be included in the final draft report. He added that the Subcommittee members will have an opportunity to comment after his remarks.

Dr. Russell emphasized that the Global Change Research Program is very important. It has the potential to increase the quality of life, health, the economy, and the environment in the face of potential global change. The effects of climate change can have consequences that affect real people in real time, not only for the short term, but for the long term and for future generations.

Dr. Russell remarked that the program members are superb in terms of ability; skill; quality of research; and reflection about why the program exists, what is important to do, what is worth doing, and what can make a difference. This has come through in the written materials and the presentations. The Subcommittee has a very high respect for the staff, the scientists, and the extramural researchers for their ability to implement an extremely complex program under difficult circumstances. Dr. Russell explained that the Subcommittee's role has been two-fold, which has created a kind of tension. The first role is to evaluate past work and the implications of actions taken and not taken. The second role is to recommend future activities, in light of past accomplishments and present realities. The tension exists because the program's role in EPA and the federal government has changed, its mission has changed, and the world has changed. Work that was conducted 5 years ago, which was appropriate and commendable, might not be appropriate to continue. Dr. Russell stressed that a decision to discontinue certain work should not imply it should not have been done or that it failed. The Subcommittee is concerned with how to build on the past and function effectively in the new reality.

Dr. Russell noted that the program's transition toward decision support was consistent with the program's mission. Decision support encompasses more than specific decisions; it also includes building the capacity to think reasonably, rationally, effectively, and economically about relevant issues in a world of greater climate variability and potential climate change. This includes building the tools to evaluate decisions that can be made in anticipation of prospective climate change. He added that science is changing, the world is changing, and it is important to be flexible and dynamic.

Dr. Russell explained that there are multiple types of stakeholders, and among the most important are those whose actions make a difference. To a large extent, their knowledge and capacity to act is the mechanism through which the program's work is translated into future outcomes. Dr. Russell emphasized the importance of maintaining the relationship with those decisionmakers.

Dr. Russell explained that, in situations where decisionmakers know what to do and will do it regardless, input from EPA is not particularly necessary. EPA's research can be valuable, however, in the following circumstances:

- ✧ Situations that have potential thresholds from incremental change, which might not be foreseen by any of the potential actors, and could result in very intense payoff.

- ✧ Collective, social decisions, which cannot be made by one individual.

- ✧ Low-probability/high-consequence events. These include episodic impacts that have some frequency but are unpredictable (e.g., hurricanes).

For circumstances such as these, it is important to establish criteria by which the high-payoff/low-cost operations can be determined.

Dr. Russell closed by saying that the Subcommittee will give thoughtful consideration to EPA's materials and presentations. He thanked the participants and offered his congratulations for their excellent program and their efforts in educating the Subcommittee.

ORD Response
Dr. Joel Scheraga, EPA, ORD

Dr. Scheraga thanked Dr. Russell and the Subcommittee members; he has enjoyed interacting with them and was very pleased with their commitment and their fair and constructive comments. He also thanked Dr. Gamble for all of her work in organizing the Subcommittee review meeting.

Dr. Scheraga remarked that Dr. Russell's summary captured the key issues that the program members hoped would be gleaned from their efforts. He added that he and his staff were energized by the Subcommittee's insights, which will help further the program. They will continue to reflect on the recommendations and keep the Subcommittee members informed about future program developments and the contribution they have made.

Dr. Scheraga thanked Dr. Russell for accepting the challenge and responsibility of chairing the Subcommittee, Dr. Duke for his efforts as Vice Chair, and the rest of the Subcommittee members for their hard work.

Dr. Russell adjourned the meeting at 4:00 p.m.

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APPENDIX

Conference Agenda

BOSC Global Change Subcommittee

Review of the Global Change Research Program

Hilton Old Town Alexandria

Alexandria, Virginia

September 26 – September 28, 2005

Agenda

DAY ONE. Monday, September 26, 2005

8:00 – 9:00 am	Registration	
9:00 am	Welcome and Opening Remarks - Introduction of Subcommittee Members	Milton Russell Chair, Global
Subcommittee	- Overview of Agenda	
	Designated Federal Officer's Welcome and Charge	Janet Gamble (EPA) DFO, Global
Subcommittee		
	ORD's Welcome	William Farland Acting Deputy Assistant Administrator for Science, Office of Research and Development

PROGRAM OVERVIEW

9:30 am	Program Overview • The Program's Strategic Plan Director • Major Accomplishments • Budget Overview	Joel Scheraga National Program

The Program's Focus Areas

10:15 am	Air Quality	Anne Grambsch (ORD)
10:30 am	Ecosystems	Susan Julius (ORD)
10:45 am – 11:00 am	**BREAK**	
11:00 am	Review of Posters for Air Quality and Ecosystems	
12:00 pm – 1:00 pm	**LUNCH**	

1:00 pm	Q & A and Discussion for Poster Session and Air Quality and Ecosystems Presentations	
2:30 pm – 2:45 pm	**BREAK**	
2:45 pm	**PROGRAM RELEVANCE TO EPA & THE CCSP**	
	Relevance of ORD Global Change Program From perspective of U.S. Climate Change Science Program	Margaret Leinen Vice Chair, Subcommittee on Global Change Research
	Relevance of ORD Global Change Program to EPA Program Offices	Terry Keating Office of Air and Radiation, EPA
	Relevance of ORD Global Change Program to EPA Regional Offices	David Ullrich Executive Director, Great Lakes and St. Lawrence Cities Initiative; formerly Deputy Regional Administrator, EPA Region 5
3:45 pm	Subcommittee Work Session	
5:30 pm	Adjourn	

DAY TWO. Tuesday, September 27, 2005

9:00 am	Review of Day One Activities And Overview of Day Two's Agenda	Milton Russell, Chair
	The Program's Focus Areas	
9:15 am	Water Quality	John Furlow (ORD)
9:30 am	Human Health	Joel Scheraga (ORD)
9:45 am	The Integrative Power of Place-Based Assessments	Michael Slimak (ORD)
10:00 am – 10:15 am	**BREAK**	
10:15 am	Review of Posters for Water Quality, Human Health, and Place-based Assessments	
11:15 am	Q & A and Discussion for Poster Session and	

	Water Quality, Human Health, and Place-based Presentations	
12:45 pm – 1:45 pm	**LUNCH**	
1:45 pm	The Program's Evolution toward an Emphasis on Decision Support	Chris Pyke (ORD)
2:30 pm	**FOCUS on PROGRAM OUTCOMES**	
	Extramural Awards	Ann Fisher Formerly Principal Investigator, Mid-to-Upper Atlantic Regional Assessment, Penn State University
	Air Quality assessments	Ken Colburn Former Executive Director of NESCAUM; former New Hampshire Air Quality Director
	Decision Support related to Water Quality/Ecosystems	David Purkey Director, Water Resources Modeling and Analysis, Natural Heritage Institute
3:30 pm – 3:45 pm	**BREAK**	
3:45 pm	National Program Director's Summary	Joel Scheraga
4:00 pm	Public Comments	
4:15 pm	Subcommittee Work Session	
5:45 pm	Adjourn	

DAY THREE. Wednesday, September 28, 2005

8:30 am - 3:30 pm	Subcommittee Work Session	
	[Working Lunch]	
3:30 pm	Presentation of Preliminary Findings	Milton Russell
4:45 pm	ORD Response	Joel Scheraga
5:00 pm	Concluding Remarks	Milton Russell /

Joel Scheraga

5:30 pm Adjourn